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AN ARCHITECT OF NATURE

BEING THE AUTOBIOGRAPHY OF

LUTHER BURBANK

WITH BIOGRAPHICAL SKETCH

BY

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BIOGRAPHICAL SKETCH

LUTHER BURBANK—NATURALIST

By Wilbur Hall

Luther Burbank was past sixty before he could find the time he desired for the making of exact records of his innumerable and unique experiments with plants; he was seventy before the itch that had always been on him to express on paper his thoughts, reactions, observations, and philosophies could be even in slight measure gratified.

Unquestionably if he had lived he would have poured forth his naturalist's soul, and the last years would have been productive of exhilarating, pungent, and enlightening essays and books that would have greatly enriched our literature of thought and comment.

What is saved of all the treasure he had stored happens to be this volume.

He wrote and left behind him, first and last, more than a million words concerning his intimate friendships with plants, but what he felt and thought, what he aspired to and how much he achieved, the things he saw in life and learned from experience, what disappointments were his and what triumphs—the true picture of the gallant, lovable, kindly, shrewd, whimsical Luther Burbank will never be limned in his own words, except in these pages.

That it was I who came to this rare opportunity resulted on the mere accident of my writing habitually in the vernacular in which Luther Burbank thought.

Working with him on a briefer and more prosy

volume, I was interrupted by the little Big Chief a dozen times an hour with some surprised, characteristic ejaculation.

"When did I tell you that?"

"How did you happen to put that in?"

"That isn't what I said—but that's the way I would have said it!"

It developed presently that my natural idiom was so like his own that he himself could not say where something he had written left off and something I was quoting or filling in began.

For a very practical and utilitarian purpose Luther Burbank had dictated at one time and another an amazing mass of material concerning his methods, technique, experiments, and scientific discoveries in the world of plants. Browsing through this heavy pasturage with one eye open for cowslips I came frequently on paragraphs having nothing to do—or nothing immediate—with the subject-matter, but that gave me, in flashing glimpses, a vague picture of the real mind and soul of the man. I had thought of him as a "wizard of plant life"—as what Hugo de Vries, the Dutch botanist, called him: "A gardener touched with genius." I began to see him as a cosmopolite and polished man of the world, as a philosopher, as a naturalist in love with Nature and life, as a humanist at once keenly interested in man and penetrating and exact in his judgments of men. I began to realize him as an extraordinary and versatile thinker. I began to appraise him as copy!

He fell in with the project for this book with ready enthusiasm.

"Folks wonder how I've kept so young," he said, one day. "I'm almost seventy-seven and I can still go over a gate or run a foot-race or kick the chandelier. That's because my body is no older than my mind—and my mind is adolescent. It has never

grown up. It never will, I hope. I'm as inquisitive as I was at eight."

It was true. He could not pass a new house, a shop window, a patent washing machine, a ditch-digger, a strange plant, or a carpenter at work, without stopping to look or watch. He was always asking, "What is this?"—and then, "How does it work?"

This insatiable and consuming appetite of his for new information was the basis, of course, for his achievements in the plant world; more important for my purposes, it was the explanation of his incredible knowledge of life. What he knew was only the beginning of what he wanted to know. That is why his judgments were both profound and tolerant; he saw through men and events and movements and motives, but the incompleteness of all data caused him to stop short of conclusions. "Up to now," he was saying, "we are what we are because of our heredities and our environments. But this is not the end. It may be only the beginning. I don't know what the end will be; no man knows anything that is final. Wait a while. Hold your horses!"

The outline for this book absorbed him, though it was being made at his busiest season, when the press of other work on him was heavy and constant. He enjoyed every minute of it.

A phrase would give him an idea that would start him off on a half-hour's excursion into memory. A question would shoot him out of his chair as though he had been propelled from a gun, and send him scurrying to his bookshelves or his manuscript files for a reference, a date, a name, or a fact. You would be in the midst of a knotty section and he would suddenly bolt, shouting over his shoulder: "Come along: I've just thought of something!" And it would be a photograph, a clipping in an old scrapbook, or a letter that would fit right in and shed

an effulgent and illuminating light on the murky corner.

Underlying all his fun and whimsy and his tendency towards an almost boisterous exuberance was the tenderness of a mother and the sensitiveness of a child. His humour was that poignant sort which is akin to tears; just under his highest mood was a serious, deep, understanding sympathy.

A dog, a child, a tramp, an ailing woman, an unfortunate, a crippled bird—even a broken blossom on one of his own plants!—could move him to great lengths of pity and generosity. Children loved and understood him; he was the friend of all the youngsters of the countryside. The needy actually imposed on him. He had an unfailing instinct for sham—but his heart usually played his head false and made him give even to rascals and frauds.

He loved extravagant expressions and descriptions, and employed them always except when they might be misunderstood or might deceive some one.

But the moment he was talking of his work, his methods, his experiments, or his results, he was as coldly exact and meticulous as a chemist mixing high explosives. Finding him extravagant in his casual speech there were those who thought he might be extravagant in his reports, his assertions, or his claims. If they tried to test him they came out of the encounter with their fingers burned. He never made a mistake there!

The first project completed, the work on this book was begun, and for two months it went forward with Mr. Burbank ever a more enthusiastic and ever a more helpful and generous collaborator. He never tired of it, though he was often pitifully and tragically tired.

Early in the spring of 1926, repeating what he had been saying for forty years, though perhaps in

different words, Luther Burbank precipitated a religious controversy that, with himself as storm centre, swept the whole country and cast its light pretty well around the world.

He had grown increasingly impatient with bigotry and superstition as his own first-hand acquaintance with Nature and science had developed; the trial of a high-school teacher in a Southern State for the "heresy" of teaching Darwin's evolution aroused him to a conviction that he ought to speak out, without mincing words, and declare for truth.

"People respect me," he said, in discussing his programme. "They know that I am honest and that I haven't an axe to grind. They like me because I like plants and they trust me because I have never misled them. I guess, if they know me at all, they know I'm a fairly decent, law-abiding, ethical sort of man, and what I say would carry weight with a lot of folks who wouldn't listen to others. The time has come for honest men to denounce false teachers and attack false gods."

In a memorable address in a San Francisco church Luther Burbank declared to the world his belief in righteousness and the highest spiritual development and his utter unbelief in the mockery of dogma.

A whirlwind of hatred engulfed him within twenty-four hours, tempered only by fluent and admiring congratulations from thousands and thousands of the thoughtful. If he had contented himself with his message, this storm would not have affected him, for he had weathered several similar ones before and had come off unscathed. But he was misled into believing that logic, kindliness, and reason could convince and help the bigoted.

I was with him during those weeks almost constantly; I saw him growing tired and harassed, not by the dispute or the vilification heaped on him by the regenerate, but by the physical task entailed. He

tried to reply to all the letters, using mild but fearless good sense with those who attacked him, and amplifying his original statement for those who supported him.

He fell sick. The sickness was fated to be his last.

What killed Luther Burbank, at just that time and in just that abrupt and tragic fashion, was his baffled, yearning, desperate effort to make people understand. His desire to help them, to clarify their minds, and to induce them to substitute fact for hysteria drove him beyond his strength. He grew suddenly old attempting to make reasonable a people which had been unreasonable through twenty stiff-necked generations. His age, his long life of exacting physical labour, and his pitiful attempt to give sight to the wilfully blind brought him to his bed.

He died, not a martyr to truth, but a victim of the fatuity of blasting, dogged falsehood.

No sunnier man ever lived than Luther Burbank.

It was one of his cherished illusions that he was "an old growler." He did growl. He growled in a good-humoured, whimsical, ludicrous fashion that deceived no one. He growled mostly at himself, though sometimes at people or about people who were "delaying the game." Never, though, did his growling hurt or wound or really convince. It was one of his games.

His laughter was ready and contagious. He could not tell a funny story, though he often tried, and would get more enjoyment out of his own inability to approach the point with the delicate abruptness of the born yarn-spinner than he could have got from the best jest ever coined. What he could do was to wring the neck of a proverb until it was funny, or put a situation into a few excruciating phrases, or twist an otherwise laboured statement into a terse and pungent epigram. Perhaps the best, but certainly one of his most characteristic epigrams was

the one, called forth when some well-meaning acquaintances caused him a great deal of worry through ill-advised efforts in his behalf, that is to be found in this volume :—

" I would rather have a dozen enemies than one fool friend ! "

Merry, humorous, whimsical, loving life and loving laughter, Luther Burbank radiated a personality that drew towards him every one he encountered. Strangely enough, this appeal he had for people attracted them even through correspondence or through the less immediate agency of the newspapers and magazines. Thousands who had never seen him felt affectionately towards him; after his death messages poured in for weeks, from all over the world and from all sorts and conditions of people, and almost without exception they wrote proudly that they had always respected, honoured, and loved him.

What was this aura—this radiance—that communicated itself to men, women, and children everywhere? Luther Burbank wrote comparatively little for publication; his interviews in newspapers and magazines scarcely mirrored the man; true, hundreds of thousands saw pictures of him, printed or on the silver screen, but, in this day when every one from champion sprinters to little princes in the throes of baptism is in the " weeklies," it seems remarkable that he was singled out of the ruck. The explanation that he loved and worked with the flowers that speak every language and to every age is scarcely adequate to explain the universal love called forth by this quiet little man.

Perhaps his own theory of life and the future contains the soundest explanation.

Luther Burbank believed neither in heaven nor in hell, in the transmigration of souls nor the translation of the body.

The ultimate doctrine in his creed was an unshaken faith in the Immortality of Influence.

For him "the life everlasting" was a phrase—a figure of speech. He had as little curiosity about the unknowable as any man who ever lived, and considerably less concern with the future. For him life overflowed with wonder, beauty, delight, and the work he found committed to his hand, and whether anything was to go on for him or not interested him not a whit. Sufficient unto the day was the heaven thereof!

But he did know and confess an abiding faith in the everlasting and eternal and all-important power on the race, the world, the scheme of things—on all life—of influence. To his mind the influence shed by a bad man was that man's own reward and punishment; the influence of a good and pure and worthy life was pervasive and ever-living. And there was a touch of the mystic about Luther Burbank. He actually realized that influence, good and bad, as a tangible, concrete, observable power in the world. He could feel the effect on his own life of the Judas Iscariots of time as perceptibly as of Jesus Christ; the eternal malevolence generated by tyrants, assassins, inquisitors, gunmen, and moral perverts was to him as potent for evil as the everlasting goodness and altruism of the Gautamas, the Saint Johns, the Constantines, the Emersons, the Clara Bartons, and the Jacob Riises. You could not, he said, either thwart or kill the influence of human lives.

He lived in entire confidence that good work well done, sincere motives, and loyalty to high ideals formed the whole duty of man; to these he added, for the creation of a real heaven on earth, the single essential, Love. As far as in him lay he lived his creed; he died without in the slightest amending or altering it, and stories that, in the end, he recanted or turned to religious teachings or teachers for consola-

tion or comfort are, at best, apocryphal; at worst, impudent falsehood.

No man, in death, ever presented a countenance more beautiful, peaceful, or serene. He was like a child asleep.

The hand falters and fails at an attempt to describe Luther Burbank clearly for those who never saw him, and for those who, having seen him for a moment or an hour, caught only a meagre glimpse of him as he was.

Small, lithe, slightly stooped, with knees and elbows bent a little from long years of the hardest physical labour, Luther Burbank was yet so stamped with the "outward symbols of an inward grace" as to stand out in any crowd as sharply as a lighthouse in a fog. Everywhere people recognized him as "Somebody." His personality flowed from him almost visibly.

He had a peculiar indifference to the looks of his clothes coupled with the most meticulous care as to their quality. The result was that, while he looked most a tramp at a casual glance, close scrutiny identified him as well-dressed. In his gardens, no matter how dirty, warm, or dishevelled he became, he was always more picturesque than he was ordinary; he had a way of wearing his hat, pulling a muffler about his neck, or slipping on gloves that gave him an indubitable air of gallantry and personableness. If he had been a banker, he would have been famed as the best-dressed man in town!

His energy, his enthusiasms, coupled with his high spirit, combined to give him an almost boyish appearance, despite his silvery-white hair and the deep lines that experience and laughter and grief had carved in his face. Sculptors said he had a perfect head. All his pictures show beauty, in the face as well as in the set, shape, and size of his head. The growth of his mind and soul registered itself on him: if at forty he was a good-looking man, at seventy he

was strikingly and arrestingly beautiful. There is no other word. He was never handsome.

His eyes were a deep and placid blue, and a little roguish. On rare occasions they would darken and narrow and snap—but he was angry seldom. When he was he did not raise his voice. Occasionally he would "pound down"—as Betty Jane, Mrs. Burbank's niece and ward, once said—when a man or an incident tried his patience too far, but he was always calm. He could use simple, chaste, elegant English words, in a quiet tone of voice, without profanity or expletives, and make a transgressor feel that a jail sentence would be a kindness compared to one of Luther Burbank's rebukes. . . . There were times when his English was not so chaste. He had a profane vocabulary; on rare occasions he unlimbered his big guns.

His movements were quick, accurate, efficient. His hands were supple and very strong: he had that deftness that marks all experts, whether a great batter, a swift telegraph operator, an old lady knitting, or a finished painter at his easel. He never made two motions where one would do; in picking up a pen he did it, instinctively, so that it was ready to lay to paper—and he always wrote with his pen between the index and second finger, supported by the thumb. When he was grafting or budding or pollenizing his hands were like dragonflies above a pool.

He clung to "boiled shirts" to the end, only toying with more modern patterns, which he would buy extravagantly—and never wear. He had as many pairs of shoes as a leading lady, and gloves enough to start a store. And yet he was frugal in most things—not stingy, but habitually New England. His food was of the plainest, his tastes simple, his pleasures inexpensive ones. On his wife or little Betty, on tools or equipment for the Farms, on photographs for his bulletins, he spent money like

water—had, in fact, to be watched and restrained. He was a queer admixture of a little, old-fashioned, careful Massachusetts bachelor, a gnome, a genius, a prankish boy, a spendthrift, and a temperamental artist. More exactly he had in him a little of all the most lovable and attractive and desirable traits of humankind—he was an epitome of the best of the race. Plus a modicum of something careless observers thought conceit. It was not egoistic complacence. It was a boundless pride in The Work. As the man who was doing that work, Luther Burbank thought considerably of Luther Burbank. As Luther Burbank, citizen, husband, friend, he did not rate Luther Burbank above any other law-abiding and peace-loving gentleman. Sometimes he was a little chagrined at the antics of the latter individual; apparently from his earlier years he was filled with amazement and delight at the achievements and triumphs of the former.

We laid Luther Burbank to rest under a cedar in the yard of the old homestead in which he lived for forty years and on the grounds of which he did most of his revolutionary and incalculably valuable work for his fellow men.

AN ARCHITECT OF NATURE

I

BACK of every plant, every shellfish, every burrowing rodent or ravaging animal, and back of every human being, there stretches an illimitable and mysterious heredity, about the nature and influence of which scientists and the wise men spend their lives in research, speculation, and conclusions. Little as we know of this subject we have pretty generally agreed that the new-born child has a heritage of tendencies and inclinations which furnish the foundation or ground-work from which he must build his house of Life.

But it is only the foundation, I think; the superstructure is built by environment. Heredity is the shape of the edifice, its position on the ground, whether a hillside or a plain, a rugged rock or a piece of shifting sand; environment is the architect of the structure. Probably I have used that word "environment" more often than any other man who ever lived; if I seem to put stress on it as these pages grow, it is because seventy years of interest in plant life and of wholesale experimentation to discover, test, practise, and then codify the laws underlying that life have compelled me to the belief that environment is the great moulding force behind the steady upward progress of the universe.

My own heredity gave me a ground-plan for my life that called for an edifice sturdily built on the rock of knowledge and fact, and yet that was plastic enough to enable me to use a front elevation strangely like a house of dreams—a veritable castle in Spain. Behind me were hard-headed practicality, shrewd

Yankee thrift, and insistence on an exact basis for reasoning and planning. At the same time there came to me, in vein and nerve-system and brain-cell, the imagination, the tendency to dreaming dreams, and the instinct to create that impelled me to invention, to inquiry, and to the seeing of visions.

My father, Samuel Walton Burbank, was a New-Englander of pure and unmixed physical strain, but it was not the shallow soil, the rocky structure below, the hardness of labour, the rigour of the winters, and the austerity of the people about him that he saw; he was a man of imagination and a facile mind, and he loved beauty and the sunshine and pleasantness of the land, in its garments of spring and autumn, and was influenced by them. My mother was shrewd and practical, of a nervous temperament, quick and impulsive, yet kindly, intelligent, and with a great love of her garden. She had an unusual bent for making things grow, whether from domesticated seeds or from bulbs or cuttings or roots found in the woods all about; one of my earliest recollections is of the beauty and peace and fragrance of that old-fashioned garden of hers.

My birthplace was the brick house on the Burbank farm in Lancaster Township, near Boston, Massachusetts; I cannot but believe that its diversified nature and activities were strongly influential on my life. The farm work, the pottery kiln my grandfather built and that led to the foundation of a brickyard, the wood-lots from which were taken the fuel supplies for house and kilns, gardens, berry-patches, the sugar bush, and other activities, not only kept a small boy busy, but kept him interested, since there was never any long stretch of monotonous work—that murderer of enthusiasm and destroyer of the sheer fun of labour! Near by and all around us were manufacturing plants of the most diverse kinds, where, at that time, something of almost every fabricated article used in growing America was made.

Physically, too, the old Lancaster farm was a broad education to a boy full of curiosity and keen to put his nose into all sorts of businesses and natural wonders. Massachusetts was—and is still!—a good place in which to be born. I can remember now the keen sweetness of the air on sharp mornings, the sun on snow or on green carpets of grass on the rolling land, running up sharply, here and there, to hills where the ribs of the earth were revealed in rugged outcroppings of rock; I can hear the scoldings and makings-up of birds, the sharp crack of ice on a pond in winter, or the croak of frogs in the odorous evenings of June, and at all times of the year the welcome sound of a shrill voice calling me to supper. New England has something all its own—an atmosphere of rugged beauty, of kindliness hidden behind a brusque manner, that its people absorbed from the land; it is a country full of surprises and discoveries: lost ponds, unexpected vistas, hidden vales, villages cupped in unlooked-for hollows—unanticipated, breathless sights of the distant sea! I do not think I was more sensitive to beauty than all the others, but perhaps I exclaimed about it more. It never failed me. And it never failed to excite and stimulate me.

Our Lancaster Township was a splendid kindergarten for an inquisitive boy. Within a day's travel I found and studied a great part of the geographical forms that mark the fascinating surface of the earth: it was not from books that I learned what a cape may be, a promontory, a table-land, a mountain, an inlet.

Thoreau was beginning to translate Nature into our American language at that time; through his eyes New-Englanders saw beauties they had missed before. His exuberant joy over the mountains and inter-vales, the valleys and ponds, was communicated to me. I fell in love with my own country, and its various and peculiar charm delighted my boy's heart and mind. I might add that the variousness of natural things in New England extended to the

weather, but if I said that my New England friends would charge me with being a Californian now, and prejudiced.

As a child, my mother and sisters told me long afterwards, I was always a lover of flowers. I don't know whether it was the bright colour or the perfume or the texture, or all three, because I certainly don't believe that I was a child-prodigy or a naturalist in my cradle, but certainly I have been told anecdotes enough of myself to show that I could be kept quiet and happy if I had a flower to hold and admire. This instinct or passion or preference continued after I grew old enough to choose my own activities, but I was a healthy, normal boy, I guess, and I can well imagine that flowers appealed to me in inverse proportion to the amount of time I had to spend hoeing them or fertilizing the ground or digging up bulbs in the fall. I cannot remember that I was more interested in flowers or, indeed, in plant life than I was in everything else about me. To the contrary, I am sure that it was life that absorbed my attention. I had no early tendency towards science, but I had a consuming curiosity—an inquisitiveness—about life-forces and processes and miracles of Nature.

One incident, written clearly on the tablets of my memory, concerns a winter-day discovery that gave me a great deal to think about. I was heartily tired of winter, I remember, as a growing boy in New England was likely to become, and was walking in the timber-piece, perhaps moodily, and maybe kicking up the snow and calling it names, and perhaps punished for my petulance by stubbing my rebellious toe against a hard-hearted old New England rock, when suddenly I saw a green place ahead of me. I could not believe my eyes. There were tall grass, bright, fresh, spring-like shrubs, and vivid vines, and on it all played sunshine that was almost tropical in its white intensity.

I am sure I must have hurried forward, forgetting

my rebel mood, to find that this was all real—a sort of winter oasis of green in a world of monotonous white. It took me some time to make out that here there rose one of those marvellous springs sometimes found in wintry countries that brought to the surface enough heat so that no snow could remain on it, and so that vegetable life could get a foothold and maintain itself in the bitterest weather. I studied the phenomenon intently. Very dimly there began to grow in my mind vague questions as to how these plants and grasses and vines, their neighbours and cousins and brothers all dead and withered under the snow, or else dormant and waiting for spring, could adjust themselves to this summer-in-winter environment. Why, I asked, didn't they follow the traditions of their families and die with the fall, or droop and shed their leaves and hibernate, no matter what the warm water brought to them in the way of a miracle of equable temperature? Certainly the lycopodiums, the beautiful trailing partridge berry, the sedges and grasses, and here and there an early sprouting buttercup, should have known better, the way they had been raised and with their decent seven-months-of-summer ancestry behind them, than to flaunt themselves so shamelessly in this unfilial winter blooming!

I am sure now that my first thoughts—very dim and vague, as I say, and only a boy's surface wonder, instead of a scientific hypothesis—concerning the power of environment in the miracles of plant variations came to me in that hour. It was late when I started home, and I could hardly wait to get there to tell the folks what I had found. To them it was no miracle; they saw in it no half-revealed secret stolen from Mother Nature's cupboard of marvels; but to me it was the most wonderful thing that had ever happened. It turned me to watching and studying and comparing, and when there fell on me the influence of an older mind trained in the processes

of Nature, I was wide awake to make the most of the opportunity.

This older mind, that exerted itself strongly in shaping mine, was that of my father's nephew, Levi Sumner Burbank, a man who had been well educated, who had a bent for the natural sciences, and who certainly had a remarkable power of exposition and explanation, so that what he talked about was alive and exciting and never dull and tedious. Cousin Levi had been a professor in Paducah College, and had read more books and understood them better than any one else I knew. My own father was well read and my mother was versed in a knowledge of simple things, but Levi Burbank had matters at his fingers' ends and could talk of them fluently. He was interested in Nature and her processes and he knew enough of such laws and speculations as men had then formulated to open many doors for an avid boy. It was he, I think, who may have crystallized my formless thinking and shaped my vague theories until he had made me want to know, not second-hand, but first-hand from Nature herself, what the rules of this exciting game of Life were.

These, I am sure, were the factors that led me to my career. My heredity gave me the basic plan for my building; the environment of that New England farm and the influence chiefly of my Cousin Levi showed me early something of the form the edifice was to take.

Afterwards I had the beginnings of education along many lines, but in my formative years I was moved only by enthusiasm, a love of Nature, a great and insatiable curiosity, and a high regard for facts as against theories. When I began to work I had no elaborate equipment—I had a garden patch; I had no microscope and Gray's botany—I had a hoe and a pair of overalls; I had no fixed and inflexible scientific education—I had a voracious appetite for knowledge. I have studied and experimented

with plant life for almost seventy years since then; I have watched men and their motives and movements with interest and curiosity; I have regarded the progress of the world and what we call civilization; I have tried to look beyond war for its causes, beyond poverty for its economic germ, beyond ignorance for the sapping parasite from which it grows in the human mind, beyond bigotry and superstition for the human weakness and fear that breed them; I have wondered and questioned and experimented and observed, from the beginning until now, with no more equipment than the mind of one inquisitive and a lover of life, and now I look back down the years and try to set forth here something of what I have observed.

I had a taste for drawing, and for a time I studied that art seriously; I had a good many inclinations towards the practice of medicine, and I took up that training; there was every opportunity for me to go into manufacturing, and I was given a place in a factory and for many months believed that I had, perhaps, found my work there. My employers felt this even more strongly than I did, particularly because, almost at once, I found short-cuts which enabled me to improve on their methods. Several of the devices which I invented were adopted and made a part of the factory equipment; I was told that I could advance myself rapidly with them, and my wages were, for that period, very high as a result of my adaptability and the inventive faculty I possessed. But, without my being fully aware of it, Nature was calling me to the land, and when there came to me my share of my father's modest estate I could no longer resist the call.

In Lunenburg Township, not far from Lancaster, I found seventeen acres of unusually fine soil that was for sale. On the place was a good old house, and, although some of my friends tried to dissuade me, and the men at the factory told me I was making a mis-

take, I bought this property and set myself up as a market gardener. It was my notion that the garden would pay its own way and leave me not only a field for experiment, but also the means with which to work; oddly enough it was not my instinctive desire to investigate the laws of the plant world, but a cold necessity which pitched me, as we say, "neck and crop" into plant experimentation.

Immediately I began this vocation of mine I learned what all of us have to learn who enter the sober business of Life—namely, that I had not been the first to think of raising produce for the market. In short, I found myself in active competition with well-established and experienced market gardeners; of course I learned all the tricks of the trade as regards cold-frames, hot-beds, the use of water and fertilizer, and the cultivation of the soil, but my competitors all knew these secrets and used them better, probably, from years of experience, than could I, a mere youngster. This competition made me a serious student of the methods by which Nature produced variations in plants, because I soon determined that success could come to me only through raising better vegetables and delivering them to the market earlier than any one else could do. Taxing my wits to find a way to make my garden pay, I came to my first constructive contact with the mysteries and miracles of Nature, and that contact resulted in my life-work.

Better vegetables, I saw at once, meant not only the best seeds and roots to be had, but the best that could be produced. In those days, with very few exceptions, no one had paid much attention to this ideal—this "best that could be produced"—and what we had to take was what we could get. That set me thinking. To produce vegetables more cheaply than the other gardeners meant cutting corners in production and marketing, and there my Yankee instincts, I suppose, served me well. But what instantly fascinated me was the thought of

producing vegetables of fine quality and getting them into the market ahead of every one else. Here was a goal for any inquisitive and active mind! Here was something you could get all excited about! Here was a place to use wits and ingenuity and inventive faculty and another faculty that, at the time, I did not know I had, even latently—the power of choice as between two apparently identical varieties or even between two apparently identical plants. Looking back, I envy myself the thrilling and inspiring research and experiment that these considerations opened up to me, as though by magic.

My mind went back to the winter garden I had found in the woods as a boy. There Nature had deviated from her apparent law of seasons and produced summer plants in the dead of January. How? Obviously the deep-flowing spring, with its warmer waters sufficiently contrasted in temperature with the bitter cold of New England to temper the atmosphere where they rose, made growth possible, but I knew enough to know that vines and shrubs and flowers grew according to their season and withered according to an hereditary tendency that had impressed itself on them through thousands of generations of growth. The warm spring accounted for the equability of the temperature in that spot, but it did not account for the luxuriant and lush growth of plants that should be dead. What I had supposed was a fixed and immutable law of Nature was not, then, fixed and immutable at all. Or, better, the law was there, but I had misinterpreted it. What was the influence behind this phenomenon?

It was presently clear to me that hereditary traits and characteristics could be overcome, modified, changed, and adapted. That much, though perhaps not in so many words, I had for a starting-point. I began to experiment with plants in a crude, superficial way, without any order to my trials and without keeping any record of results.

I found certain plants that grew more rapidly than others in the same row, and some with foliage better suited to the purpose of a market gardener; as, for instance, such as would give the fruits a better opportunity to mature, or such as would better shelter delicate ones, and so on. As the season advanced I marked individuals that bore more than their fellows; here and there I found those that bore bigger produce, or more succulent, or earlier or later. In each case I was looking for an improved variety—improved in one respect or in two or three—and when I found a plant that was willing to take a step forward, I tagged it with a medal of honour and so marked it for further promotion.

When harvest time came these marked plants were saved, and their seeds or fruits went into my "stock" for the next year's planting. Stored in every cherished seed was all the heredity of the variety, and in addition a tiny spark of genius—of improvement—that environment (or, in some cases, perhaps, a mere chance) had placed there. In the beginning I had no assurance that the improvements would be absolute and fixed in the second generation, but after a time I began to see that they were, and that there was certain to be at least part of the second year's growth that would show all the finer characteristics of the marked plants, and a tendency to improve on their improvement.

It was not long before I knew that I was on the right track. My start had been made.

II

THE place where most stories of my work would begin, I suppose, is with my finding of the potato seed-ball that gave me the Burbank potato. That was an important discovery to me, and it did set my feet finally and successfully on my road. But I have thought often lately that if it had not been the potato it would have been something else, for I was determined before that time to find the vulnerable spot in Nature and make her my co-worker with plants; nothing could have delayed me long, and it was only fortunate, probably, that the incident of the potato came as it did, and so hurried things on for me somewhat.

The potato story has been told again and again, often correctly, and I am only going to summarize it here. In New England we grew large quantities of potatoes, but they were generally small, of a red-dish colour, and few of them good keepers. It required no genius to know that if a large, white, fine-grained potato could be produced, it would displace the other varieties and give its discoverer a great advantage over his competitors. I tried crossing, with poor results, for the hybridized blossoms produced no seed. And selecting led me nowhere.

Then I found a potato seed-ball! I use an exclamation point. That is because—well, it was what an astronomer would use if he discovered a new solar system. A potato seed-ball was not unheard of, but it was a great rarity, and I couldn't learn of any one who had done anything about the event even when it occurred. I *did* something; I planted the seeds in that ball. I had twenty-three seeds and I got twenty-

three seedlings. From that whole number, although there were many that were an improvement on any potato then grown, I selected two that were amazing, valuable, and a distinct type. They were as different from the old Early Rose as the beef cattle of to-day are different from the old Texas long-horn.

It was from the potatoes of those two plants, carefully raised, carefully dug, jealously guarded, and painstakingly planted the next year, that I built the Burbank potato. And it was from the Burbank potato that I made my beginning as a plant-developer. Not only did the new potato prove to me that Nature was ready to co-operate and collaborate with man, but it also made me a small name and paid me some small amount of cash. Both of these were important factors in my career. They are important factors in the career of any young man, and those who affect to despise either are talking rubbish. Money and fame, if you go out after them without any other motive, are a pretty low aim, but if your goal is service, or expressing yourself, or making the world a better place in which to live, you will find that a respected name and a few dollars in your pocket will grease the runners considerably! You'll go farther with less strain on the trace-chains and you won't tire so easily on the first short hill.

Meantime there were influences in my *environment* that I did not reckon with and yet that determined my life for me. Let me give you a notion of how environment seems to me to operate and do its work on the living individual—plant, animal, or man.

It is not the duration of an environment that affects heredity; it is the amount of pressure exerted. The more sensitive the plant or the man, the more readily he takes the impressions his surroundings or situation give off. It is all a matter of vibrations—a matter of response to vibrations. In no other way than through vibrations do we get anything. You know that the camera-plate is struck with blows of

light to burn into the sensitized surface the picture you want to take. If you make what is called a time-exposure the blows are gentle, but sooner or later they make a dent in the gelatine. The lighter parts are burned deeply, and the shadows and black places are only just touched. But it is the steady tap, tap, tap of the rays of light that do the work.

We are all made—plants and fish and cats and elephants and men—of organisms built of tissue that is built of cells. The life-force is in the cells—protoplasm, made up of almost everything in the universe in infinitely minute particles. Now, because that protoplasm, which Huxley says is the basis of life, is made up of almost everything in Nature, it responds to almost everything in Nature. Protoplasm is the sensitized film on our bodily and intellectual plates; vibrations from about us strike it, and gradually they make a dent. Repetition, repetition, repetition—that is the process by which environment bends and moulds and directs and diverts and changes us. Why does the great composer choose two or three little phrases of music and work them into his symphony in a thousand different ways? Why does the orator use the same simple line again and again and again, playing with it, decorating it, embellishing it, speaking it in a low tone, then in an abrupt voice, then as a question? Why, simply to carry his message home! We say: Give a dog a bad name and you might better drown him! Because the badness of the dog is stressed day after day, month after month, until the whole neighbourhood believes he is bad, and after a while the dog himself begins to figure that there may be something in the idea.

Perhaps one of the first words I ever heard was California. Certainly there must have been talk enough about this country, for the year before my birth was the year in which gold was discovered here, and in the ten or twelve years following emigration

had set steadily this way from every part of the land. Moreover, my older brother, George, had come here in 1854, and his occasional letters (he was not a letter-writer, but a man who did things and left the talking about them to others) undoubtedly fired the interest of the older people and the curiosity of the boys. All that I heard of California day after day, week after week, from every side and source, even during a time and in a neighbourhood where slavery and the strong will of the South were lively topics, impressed itself on my mind. I do not know that I ever suddenly announced my belief that California would be the place for a plant experimenter to work; repetition, repetition, repetition, struck the storied name on my consciousness until I was as certain to go West as I was to continue plant experimentation.

This seems to me a happy moment to take one more step with you in the scientific course necessary to an understanding of much that I will write in these rambling papers on the work and memories of my years.

Remember that I was a New England boy, bred and born; my heredity might have been supposed to keep me a New-Englander, and my environment to double the urge. Instead I am writing of the certainty that I would pull up stakes and go to California. Was that chance, or an exception to the rule? Haven't I been saying that heredity gives us the foundation from which to build, and environment shapes and designs the building? The explanation is simple; it relates so closely to all that is to come that I must give it to you here.

In the first place, you must look considerably below the surface to determine just what your heredity —any heredity—actually is. For into it, through the long line behind you, have come many and varied influences. And one of the most potent and revolutionary influences is that which results on the mingling of heredities through the mating of two sexes.

We accept sex as a fact, and we accept the necessity for two sexes as a similar fact. But did it ever occur to you to wonder why Nature bothered to require two parents? I mean by that question to ask you to forget everything you know about the matter and consider it as though the whole plan of life were being instituted for the first time, and you were sitting in on the conference on ways and means. You would agree that there must be a law to compel the individual plant or dogfish or toadstool or lynx or ape or man to desire to live, otherwise the first discouragement met with would be the end of that enterprise! You would agree, secondly, that the individual must be compelled to want to reproduce himself, or else the job of starting him off would have to be done over and over again. So you would be unanimously in favour of the law of self-preservation and the secondary law of the perpetuation of species. Very well; why not let each individual leave a cell somewhere in a warm protected spot and then lie down and die, assured that the nested cell would be born into a copy of the original, and the species or family would go right on?

I don't think it was accidental—this arrangement that required two cells to meet and join to reproduce themselves in a new life. Not at all. I think it was for the very best reason that there is for anything in the miracle-working of Mother Nature. I think it was because she knew that sameness, monotony, exact re-duplication over and over again would make this world the dullest point of light in the whole universe. Nature required variations, change, development, growth. She may or may not have wanted improvement—there is a great quarrel among the scientists on that fine point, and I'll pass it by for the moment. She did demand change—variation—a constant blending of old stocks to make new forms, shapes, sizes, colours, and to make it possible for the individuals, whether plants or

animals or humans, to move about and adjust themselves to new conditions and so give the earth the diversification and interest that it has for us to-day. If the aster had re-created itself from one cell, it would have been an aster, and no power on earth could have developed it into a coreopsis to the end of time; if the Burbanks had been blacksmiths, and none of the strains brought into the family by the women they married had exerted their hereditary influence, I should have been a blacksmith, and probably a poor one, and nothing could have changed me or given me a different chance.

Nature saw all that, and, by the simplest and most adroit single stroke that the whole history of biology records, made it impossible. She went a step farther, and attached certain penalties to the single-cell or single-strain method of reproduction, so that what we call inbreeding is known to be a very risky thing to try, and cousins who marry often bring forth weak or sickly or defective children. No, Nature wanted variations, and she made it possible to have them from the very beginning—indeed, made it pretty difficult not to have them. And there is something you won't find in most of the text-books, and I think you will find it something worth musing over.

This cunning provision Nature made brings us back to my discussion of the influence of the environing gossip and excitement concerning California on my New England heredity. That heredity had in it, not only the Burbank strain, but it also had in it the pulls of my father's mother's heredity, and his grandmother's and hers, and so on, back and back, until I was related distantly, perhaps, to half the white people in the world; more than that, it had in it the pull exerted by the heredity of my own mother, a Ross, and her people, on both sides, spreading laterally and running through the tree of the families of earth until, on her side, I was probably related to

the other half of the world's white inhabitants. In short, I was a product of all my heredity. And Mark Twain was not altogether joking, maybe, when he said that he had to abandon his efforts at getting up a genealogical tree for himself when he discovered that it included a horse-thief or two. If there wasn't a horse-thief or an embezzling bank cashier somewhere back in my line I am certainly different from most folks; if you want to make a family tree that will really tell the whole story you will have to go on below the ground (something I notice the genealogists are all too canny to do!) and follow the roots from tap and anchor main stems through the laterals and branches to the very tiny little threads at the ends—and even then you would only be starting your task.

I had, you can see, a variety of influences on me that were purely hereditary. Who can say whence came the strain that responded so instantly to the repeated call of California? But it was there, and a tug-of-war probably went on, without my knowing it, between that strain and the hard-headed New England blood of me. For New-Englanders are notoriously fixed and set sorts of folks; they are the oldest Americans, they are well satisfied where they are, they are conservative, they are not always chasing will-o'-the-wisps. Even their famous seamen—wanderers, pioneers, and adventurers though they are and always have been—usually come home. The New England heredity exerts a strong influence on all its youth to strike their roots still more deeply into the parent soil. It was a battle between the conservative that said, "Stay where you are!" and the radical that urged me to get out and go West.

For you must not suppose that heredity is only a matter of red hair or speaking German or bearing a family resemblance to your father and grandfather. Heredity is also a matter of ideas, ideals, habits of thought, points of view, temperament, and all the

other mental and intellectual aspects of a man. The heredity of the Navajo Indian is not only towards a lean, long frame, an aquiline nose, and a natural ability as a hunter and a horseman, but it is also towards being a wanderer; the heredity of the Hopi Indian is not only towards being shorter, squattier, heavier, slower, and broad-nosed, but it is also towards being a town-dweller and a trader, with a timid sort of agriculture on the side.

You see, we are a bundle of hereditary strains and tendencies; environment may play on one or two and not on the others, or it may act strongly on half a dozen or all of your inborn characteristics. In my case some untraced tendency was towards movement away from the home-place: my sensitized plate was struck repeatedly by influences leading towards California. I had no choice in the matter. I was bound to go!

Now we come to another very important influence that operates on our hereditary tendencies to change and modify and direct them into new channels—the influence of education. Education is a form of environment—an intellectual environment that is as definitely moulding and directing as the pressure of a rock on a plant to force it to creep towards the light, or of a spring of water to give it the strength to grow taller than its kind.

I am not speaking of my education by books in the schools. I am a good deal of a crank about the education of children, and probably I won't be able to contain myself on that subject as we go on; right now I have in mind the influence on me of the greatest scientific thinker of our age: the man who changed the whole meaning and language of science—Charles Darwin. In Lancaster I had got hold of a book of his: *The Variation of Animals and Plants under Domestication*; it opened a new world to me. It told me, in plain simple sentences, as matter-of-fact as though its marvellous and startling truths were common-

places, that variations came from cross-breeding, and that these variations seemed to be susceptible, through selection, of permanent fixture in the individual. While I had been struggling along with my experiments, blundering on half-truths and truths, the great master had been reasoning out causes and effects for me and setting them down in orderly fashion, easy to understand, and having an immediate bearing on my work. I doubt if it is possible to make any one realize what this book meant to me.

Big as the book was, and significant as it was to me, its influence over me was heightened and its lure for me was increased by the uproar with which its author's theories were received. In 1859 Darwin had published *The Origin of Species*, and, just when *The Variations of Animals and Plants under Domestication* was stirring me all up, he shook the world with his *Descent of Man*. Almost immediately the storm broke, especially in the New England churches and homes. The theory that man had descended from an ancestry common to that of the apes—Darwin never said anything about his *descending from monkeys*—was blasphemous, scurrilous, infamous, and other things even worse! Darwin was banned from the churches and from most homes, and those who read him were considered as bad as he was. Perhaps I was always "ferninst the government" as they say; at any rate, the man every one was discussing and most of them were damning was for that very reason interesting to me, and the controversy—a rather one-sided one in our neighbourhood, I remember, since there were few to defend him—only served to inflame my interest in every word he wrote. The blows his personality and phrases struck on my sensitive mind were steady, sharp, and persistent; my New England heredity was outweighed by the pressure of my environment—the talk of California, the furore against Darwin, and his clear and illuminating book—and I pushed out and away.

I check myself here to be sure that I am telling the whole story, and a little guilty feeling comes over me. The fact is that there was an immediate cause for the ultimate act of severing home ties and setting out for the West. I am sure now, and I think I was sure a few months after my arrival in California, that I was certainly destined to make the break, but if I had been asked as I boarded my train for the great adventure just why I was going so far away, with such apparent suddenness, I should have replied sadly, that it was on account of an unrequited love.

The story of this early romance of mine has crept into the newspapers now and again; the truth is that I was very deeply fond of a beautiful young lady who seemed to me, I remember, less ardent than I was. A trifling disagreement, two positive natures, probably hasty words—and I determined that my heart was broken. To be frank, I think I gave that affair to many as my reason for coming West.

I find, on looking back through letters written home at the time, and on considering all the facts that there was another motive behind my decision, although I am not at all sure that I was conscious of it at the time. There are in those first California letters several references to the sense of freedom California gave me, and now I can say that I was undoubtedly influenced by a desire to be my own man, unadvised by family or friends, and no longer compelled to explain or apologize for my choice of work or the methods I employed in getting at it.

It was in 1875 that the stories of the West, Darwin, my unconscious sense of restraint in New England—and Mary—sent me packing. I was twenty-six years old—a small, wiry, active young man, observant, alert, inquisitive, and full of ideas about what I was going to do. A few very definite fundamental laws of Nature were fixed in my mind as a basis on which to build. I had read more science

than most youths of my acquaintance, and all that I had read had been illuminated and crystallized for me by Darwin. In my luggage I had ten Burbank potatoes that I had been permitted to retain when I had sold the new variety to a New England seedsman. They were to be the foundation of my fortune and the beginning of my fame. I meant to round out both fortune and fame. It was some years later before I reached a turn in my road where I had to decide between them and my work: that is an interesting chapter that must come in its turn. For the moment I was pretty definitely fixed in my ambition, and the bigger, broader, more important meaning of life hadn't come to me.

III

THERE was a time when, looking back over my early years, I was inclined to glory in the fact that I had made a success for myself and of myself when I had started humbly and without much money, or a college education, or what we call a silver spoon in my mouth. I classed myself, I expect, with other Americans whose names are known and connected in every schoolboy's mind with poverty bravely endured, hardships undergone, and mean tasks well performed—in short, I was rather fond of the American log-cabin-to-President tradition.

Now I wonder if this whole business isn't rather empty. I don't believe I ever had a moment's pity for myself because I was having a hard row to hoe as a young man making a start in California. The fact is that America is great not because her poor boys have struggled through difficulties and become successful, but because there are here great difficulties to be overcome. The struggle has brought out the best inherited tendencies and potentialities in her men and women when their environments have been poor or simple or their chances meagre. It is this environment that is changed by the American environment of education, ambition, opportunity, and the rivalry to excel; these factors or forces operate, when the heredity is sound, to give us our Presidents and our captains of industry, our thinkers and writers and artists and scientists and leaders in every line.

A very moving tale could be woven out of my first years in California, but an old letter which I wrote back East, a few days after my arrival, shows me that I had about everything that would make life

interesting and worth living to a young man with great ideas of what he was going to do with himself. The first sentence I encounter, in looking at that epistle of my youth, recalls one of the favourite stories of the log-cabin-to-President writers who have fooled away words on my biography: the anecdote has been embellished and worked over until you might believe that I began my Santa Rosa experience in a chicken-coop because I couldn't afford better quarters. Well, here are the facts:—

"Brother Alfred and another fellow have put up an 8 × 10 shanty and I expect to go to keeping house with them to-morrow. We bought crockery, bed-ticking, etc., last night. . . . I shall not look for work for a week. The change of climate has given me a cold, as it does nearly all, but I never felt so *contented* and free from mental disquiet, and never slept or ate better in my life.

"A fog is hardly ever seen here—the wind never blows hard. I wish you could see California fruit. I bought a pear at S. Frisco when I thought I was *hungry* for 5¢. It was so large that I could only eat ⅓ of it. I threw the rest away. Grapes are so abundant that all are allowed to help themselves to the nicest kinds at the vineyards. There is no skin to them and very small seeds. The pulp is the whole grape. If you try to squeeze one out it will split like a plum. They are very sweet and nice and are so plenty that they are often used as hog feed."

* * *

The italics were those of my youth: also the hand-made abbreviation for San Francisco.

You can't feel sorry for that boy! In fact, I envy him! I would give a good deal right to-day to swap places with him; to go out to-morrow and buy crockery and bed-ticking, etc., for the "shanty" and to start housekeeping with Alfred and his friend (whose name I have long since forgotten; he was with us only a few weeks). That shanty is still standing in Santa Rosa, and is now used as a shed or chicken-coop. That is how that story got going; it is too bad to correct so beautiful and inspiring an error,

but you must make the best of it. I didn't begin life in California sharing my roof with the chickens, and it is quite apparent that I was well-fed and happy when a bunch of grapes could send me into rhapsodies and "a" of a five-cent pear could satiate me!

Another letter, written at about the same time, has some valuable material in it; it shows how I was impressed by my new environment, and it also shows that I early developed a caution in public utterances that stood me in good stead many times later. This letter is marked "Not Public," and it reads, in part, as follows:—

"The reason that I give this description of Santa Rosa outside my general letter is because if it is generally known what a place this is all the scuffs would come out here, get drunk, and curse the whole country, so don't let on to *anybody* outside the house what sort of a place this is *except* that I am delighted with it.

"I firmly believe from what I have seen that it is the *chosen* spot of *all this earth* as far as *nature* is concerned, and the people are far better than the average. The air is so sweet it is a pleasure to drink it in. The sunshine is pure and soft, the mountains which gird the valley are very lovely. The valley is covered with majestic oaks placed as no human hand could arrange them for beauty. I cannot describe it. I almost have to cry for joy when I look upon the lovely valley from the hillsides. The gardens are filled with tropical plants, palms, figs, oranges, vines, etc. Great *rose trees* climb over the houses loaded with every colour of blossoms. Do you suppose I am not pleased to see the fuchsias in the ground 12 ft. high, the trunk 10 inches in circumference, and loaded with colour? . . .

"A *family* can live here, I am quite sure, for about one-half what they can there and far more comfortably. Meat costs but little, flour is better and cheaper, fruit is nothing almost, very little fire is needed, and such warm, expensive houses are not necessary. . . . Have given you a truthful description of my experience so far.

"I came across a directory of this country just now. I take a few ideas from it. The cause of the great growth and prosperity of this place (Santa Rosa) just now is the

new railroad which has given it a start. It is the county seat and is called the prettiest town in the state. It is noted for its polite and obliging people. . . . It is situated in a marvellously fertile valley containing 100 square *miles*. The educational advantages are ahead of any Cal. city of its size. (The above is from the directory.)"

Wasn't that parenthesis astute?

But I was always on the trail of my life-work, or the other way round! In a letter written November 9, 1875, I encounter this paragraph:—

"I took a long walk to-day. I found enough new and curious plants in a wild spot of about an acre to set a botanist mad. There is an old surveyor who knows nearly all the plants here. I am going to take a batch to him this evening. He is very much interested in them. My botany tells the names of only a few Cal. plants. Some of them *have no names*."

Charles Darwin's *Cross- and Self-Fertilization in the Vegetable Kingdom* was published in 1877, and it was not long before I had a copy. I had spent my first months in California studying the country, comparing various localities as to suitability for my purposes, earning my way with whatever came along to be done, and experimenting with plant development. I soon knew most of the native plants and herbs that came under my notice, and I remember being greatly interested in the California poppy, which I had never seen equalled for colour and profuseness of blossom—the hills being mantled with them in the late spring until it was easy to believe early discoverers might have given the opening to San Francisco Bay the euphonious title "The Golden Gate" because of the colour on the Berkeley hills opposite that entrance to the harbour. Later I had a lot of fun with the poppy: by carefully planned cross-fertilization and then selection I was able to get colour in the poppy from the clearest white to a deep red. At any rate, from the first I found plenty to

interest me and plenty to study before I came upon Darwin's new book.

One sentence in the very introductory chapter of that volume opened the door of my mind and took possession of my fancy. After discussing briefly the marvel of cross- and self-fertilization in plants Darwin said :—

"As plants are adapted by such diversified and effective means for cross-fertilization, it might have been inferred from this fact alone that they derived some great advantage from the process; and it is the object of the present work to show the nature and importance of the benefits thus derived."

Advantages and benefits! Darwin was writing of the plants themselves—I was thinking of mankind. If Nature had developed an incredible system by which plants could re-create and diversify and improve themselves *for their own benefit* and advantage, why should not Nature be induced to employ that same system *for the benefit and advantage of man?* It was my starting-point—and it was Darwin again!

You see, we have a lot of new wants coming on all the while—it is the natural thing with man. The first main want is food, then clothing and shelter. If we can get plants—not just a few plants, but all plants—to produce food, we have certainly accomplished something that is the most important of all, perhaps. Then another thing—flavour and keeping qualities—all these things are wants.

Then we need shelter. We need trees that grow very rapidly—more rapidly than those we have now. We need those that produce lumber—durable lumber, and lumber for different uses, whether for building houses or making axe-helves. There are various uses for very strong and very fine lumber, increasing all the time. We need fuel, of course, although that need is being met by development of electricity by water power and coal.

Then we need clothing. We need hemp and flaxes and various new plants that will produce more fibre for less labour and that will do this on less land without taking any more from the land. This last is a point often overlooked, yet of the greatest importance. In America we feel we have all the land we need—that we have land to spare. But if you are looking for a farm, for instance, you will find this is hardly true. Millions of acres of land are not tillable or have no water. The good land is pretty well all in use. Some of it has been practically used up and must be made over either by Nature or with artificial means before it can be used again. The best land costs so much that you can hardly afford to pay the owner a premium for giving you a whack at it. And so we are, to-day, right up against the problem of making the land do more work with less exhaustion.

We need, moreover, a great many other things that we do not now produce in America, but that we could produce. Take rubber as an example. There is a great hue-and-cry because it costs as much to put new tyres on an automobile as it used to buy a good team and side-bar buggy! We are dependent on other countries for our rubber, and there is no reason why we should be. I notice some of my friends in the rubber business have wakened up to the possibilities here—I talked to one of them about it a few years ago when he was here, and he pricked up his ears and looked as though he had caught an idea or so! We can do anything in America we set our minds and hands to doing; if we have one weakness more dangerous than another, it is the weakness of being satisfied and complacent about things—of not getting stirred up enough over our own lacks.

There is another need we have: the need for more beauty. We have neglected this aspect of life too much; we have taken what we had and not minded

very much to increase our æsthetic appetites or to feed them. We need beautiful lumber and we need shapely and beautiful ornamental trees; we want fragrant flowers—a thousand things that make life well worth living in the shape of ornament and beauty and things that, to many of us, seem superfluous, or at least not absolutely necessary. But they are, just the same!

These are only a few of the possibilities in plant breeding and development. They were possibilities when I started in, and they are still possibilities. I could see a great many of them, and I began to try to work some of them out. It is interesting to me in retrospect to recall that I was, in most senses, a pioneer in this chosen field of mine, and I think this fact stimulated and urged me on. There were no precedents to go on in plant development. Darwin had experimented with pollenization, but only for the purpose of discovering and setting down laws. He made important and absolutely new findings, but when he had made them and set them down he left it to others to make the rules useful.

There had been plant breeding in England, where they had worked with roses, and in Holland, where there had been great interest in tulips. I think, too, that there had always been a more or less unconscious selection practised, maybe all over the world. For instance, the ancients who planted figs or pomegranates undoubtedly took their cuttings from the best and biggest trees that bore well, and so they developed generally some good figs and pomegranates—by selection, without their calling it that. There hadn't been, though, any broad experimentation or research or practice of this business of improving plants so that they would be of more use and benefit and advantage to man.

Right away I found that all the facts in life and Nature are correlated; I saw that this speciality of mine, that you might think didn't amount to much

and that any first-rate gardener could contrive, was a sort of cross-country trip through the whole field of natural science. To arrive anywhere, you needed something more than a definite idea of your destination—you needed a diagram of the lay of the land all around.

But that is true generally; it is something all of us, no matter what our job in life may be, might be better off for considering. Because you cannot judge *a man*, for instance, by studying him alone, or even by studying *man* alone; you cannot know much about an elephant by studying elephants alone; you have to learn about habits and tendencies and surroundings and about the things on which the individual is dependent and which go to make him and his actions possible or necessary, as the case may be. You cannot become an authority on grasses—the grasses fit to eat and those not fit to eat (all grasses fit to eat have seeds)—just from studying grasses. No, the fact is that you cannot see all of the facts about anything by just looking at that thing itself. To learn part of the essential truth about grasses, for instance, you have to study the cow!

When you delve into one little narrow subject, such as plant-breeding, we'll say, or the barber trade, or keeping house, or operating a telephone switchboard, the more you know about chemistry and astronomy and human nature—nature in general—the more successful you are going to be. Because you know where to place each fact that comes to you in your training and your practice. You see, if you do not know where to place your facts they are not good for much. A fact is relative, and if it is placed out of its relative position it apparently is not a fact, often.

But get your facts to line up in their proper position, and everything is all right—like soldiers. A general gets them lined up, and he can march them forward to accomplish whatever he desires; so unless

facts are marshalled together—substantiate and complement each other—they are not worth much. Some people bear down on a single fact and wear it all out, but there are other facts related to that fact which, if they were brought together and put in their proper order and sequence, would illuminate a whole city street. That is what I discovered very early in my work—to get at all the facts on every side of the subject, and then when I went ahead I knew my way, and wasn't groping around or barking up wrong trees or wasting time building fine theories or unstable premises.

At that time I had a pretty good background of scientific reading. I had had ten years of actual work with plants and a life-time of interest in them and curiosity about them, and I had fundamental rules for my work pretty clearly in mind. But how could one man, in his single lifetime, have much of an influence on the vegetable world, when about all that most experimenters in any line had been able to do was to specialize on one single branch and die leaving the work unfinished? Here I was, keen to break trail in every direction—to improve ornamental trees, to find some laws about lumber trees, to make more beautiful and finer and more gracious flowers, and to give the farmers and gardeners of the world earlier varieties, better-flavoured fruits and vegetables, sturdier and heavier-bearing grains, and more profitable varieties of all sorts and kinds. It was a large order!

IV

I HAVE noticed that many things come to the man who needs them, and needs them for a really important reason. Not Fate or Kismet, not divine intervention or providence; we get ourselves all ready for the critical moment and adapt ourselves to the favouring environmental influence eagerly and instantly—as quick as a shark will grab some lazy fish! And so it sometimes seems to be almost prearranged for us. At about the time I was beginning to develop my work in a broad, comprehensive, sweeping fashion, an incident occurred that crystallized everything for me.

A man wanted twenty thousand prune trees delivered within nine months, because he was in a hurry to plant his orchard; no one could accept the order because there were few nurseries in those early days, and the ones there were didn't have the stock. I was approached. I didn't know how it could be done, but my brief experience in working with Nature instead of following set rules made me feel there ought to be some way. I had neither twenty thousand prune trees nor any place from which to get them. But I began to reason it out. I have made it a rule all my life, by the by, never to sign papers or obligate myself to anything of importance without letting the proposition lie around in my mind for twenty-four hours; on this prune-tree proposition I needed the time and took it; the next morning I accepted the order.

Now I was not only given a chance to try out some of my theories about this collaboration with Nature of which I have spoken, but I was squarely up against the necessity for doing it. For some time I had realized that there were two entirely new channels

through which to move in training plants to work for man, and this prune order made it necessary for me to put both of them into employment. First, I felt sure that I could bring about, in a few plant generations, what Nature required hundreds or even thousands of years to achieve; secondly, I saw that such experiments as I would have to conduct must be performed, not with one or half a dozen plants, but on a broad scale—literally by wholesale. In short, to borrow the language of industry, I not only had to *speed up production*, but I had to *build up and maintain quantity production!*

Nature, as I have already shown, appeared to me to demand or require or call forth variations and the adaptation of those varieties to new environments. But she had all the time there was and all the raw materials she needed; she could be wasteful and extravagant on the one hand, and leisurely on the other. She worked with birds and bees and other insects in cross-pollenization; she was assisted by all sorts of accidental hybridizations; she sowed seeds far and wide, employing floods and winds and glaciers and migratory birds and animals—these were only a few of the agencies used. She made millions of trials and had millions of failures, but she had no reason to be concerned about that. She wasn't under contract, and no one was writing her indignant letters beginning, "In the matter of the shipment of pine trees ordered from you five hundred years ago for our temperate climate, beg to advise you that same has not yet arrived." No, Nature employed the system of trial and error, trial and error, and yet eventually there was dispersed over the whole earth the multitude and infinity of plants and shrubs, vegetables, and flowers, fruits, and vines both that we find in the wild state to-day and that, working with the wild plants as foundations, man now has to fill his gardens with delight, his orchards with plenty, and his fields with wealth.

I could learn my methods from Nature, but I was not compelled to accept her schedule. I was convinced that, by following her system and learning lessons from her open book, man, with his developed intelligence and his lately acquired habit of aiming at a definite goal, could get in plant-breeding what he wanted, where he wanted it, and eventually about when he wanted it. The prune-tree order was necessarily a wholesale job, where I could try myself out in handling large numbers, but primarily it was a test of my ability to accelerate Nature's methods by intelligent employment of her laws.

The first requisite for the new venture was a sturdy but rapidly sprouting tree stock, and I chose the almond because, unlike nearly all stone fruits, it takes hold readily and grows quickly. I found twenty thousand almond nuts of even quality, spread them on a bed of coarse sand, covered them with burlap, and on top of the burlap put a layer of sand. The purpose of this arrangement was to enable us to examine the sprouting nuts daily without disturbing the roots; in fourteen days a few of the seeds had sprouted and were picked out and put in the nursery beds; as fast as sprouting occurred the planting followed, and by the last of June those almond seedlings were up high enough to be budded.

Meantime I had arranged with a neighbour to furnish me with twenty thousand prune buds, and early in July and all through that month and part of August I had a large force of experts budding the prune buds into the almond seedlings. After about ten days I found the buds would make good unions with the stalks; then, in order to force all the nourishment into them, I had to find a way to eliminate the almond side of the family without killing the young trees. If I had cut the almond twigs and leaves off summarily the seedlings would have died; instead I broke off the tops and left them hanging—there was still a connection, but most of

the strength of the little tree was diverted to its adopted child, the prune bud.

The plan worked perfectly. The prune buds took hold bravely, and in a few weeks what had started out as an almond was a prune, and flourishing mightily. By December 1, 19,500 prune trees were ready for the order, and the delighted customer said I was a wizard and paid the bill with great satisfaction. That satisfaction, I do not need to add, was mutual, because I had not only proved my theory that Nature could be hurried and used and directed by man, and in wholesale lots, but I had silver jingling in my pockets and the necessary capital to go on with the great work this first effort now opened wide to me.

Ever since that time I have worked on a quantity basis, speeded up. This does not mean that I ever overlooked quality; on the contrary, it was only to get quality, and a very definite sort of quality at that, that I was working at all. I have had as many as ten thousand separate and distinct experiments going on at one time. I have produced as many as five hundred varieties of plums on twelve trees in one short row. I have had in my gardens as many as eight thousand different varieties of roses, iris, or gladiolus. Every one of these was obtained by using natural processes or adaptations of them, and every one was there because I needed it in my search for a definite quality or characteristic. I took Nature's mind and added to it my own, that knew exactly what it wanted and was in a hurry (comparatively speaking) to get it!

How did I operate in carrying on these experiments?

This is not a manual of hybridization and selection; I fancy you would find that pretty dull reading. But the general underlying principles of the work may be mentioned, and they seem doubly important to me because they concern all life and, if they are

rightly read, will throw light on a lot of the puzzling facts of our existence and of the existence of conditions which we find about us and with which we have to contend in the struggle and loss and gain of our lives.

I have referred to the importance of combining our heredities so that we get variations—powers and characteristics and capabilities and possibilities that could not come to us from one straight and undeviating line of ancestry. Compare the Chinese and the native-born American, and you will see what "mixing up" the strains can do. The Chinese have, to be sure, absorbed several alien bloods in the centuries past, but pure Chinese has been the dominating influence on all the people. The result is that they are conservative, not adaptable, with cautious minds and reactionary tendencies, worshipping their ancestors and the past and not looking forward nor trying to improve themselves or their own conditions. Occidental influence (environmental) is beginning to stir them up some, but the hereditary pull is too strong. Nothing will radically alter the Chinese race but crossing with some other strains.

The American, on the other hand, is related to almost every white race on this planet: we have English tenacity, French enthusiasm, Celtic impulsiveness, German inventiveness, Scandinavian loyalty—some of the best and a few of the worst tendencies of a mixed heredity. The result is that we will tackle anything and, while we may brag and blow a little too much, we usually come out with what we went in after.

That is crossing; that is, in a sense, hybridization. The tiny cells in which the life force is stored meet and are united. If there is the same heredity behind each the mating is smooth and uneventful. But introduce a strange or alien heredity and there is an explosion such as you would get from touching off ten thousand tons of dynamite in a concrete

warehouse! The atoms fly in every direction; everything is broken up at once and millions of tiny constituent particles are blown entirely out of the record. Some few unite, and from them come the new individuals, having something of both heredities and yet new characteristics and characters and tendencies and potentialities not to be accounted for by anything we can put our fingers on in the past lines.

I often think that I had something to do with dignifying the word "hybrid"—I hope I did. Because hybrids are what make the world go forward. They give us our inventors and poets, our dreamers and leaders of the earth, and in the plant world they are the fragrant and gracious flowers, the luscious and nourishing fruits, the succulent and meaty vegetables. Have you ever noticed that the most intelligent, the most loyal, and the most friendly dog is usually a mongrel—a cross between two good strains, with a little sense of humour interjected from some early indiscretion on the mother's part with a dog who was not all he should have been?

This is not to say that all mongrels turn out well—most of the litter in which your smart dog was whelped will be hardly worth drowning! But the combination of heredities often eventuates in an individual pup or cat or mule or man or flower or fruit that will stand out away beyond any of his fellows, or of his parents, because from all the possible hereditary influences in all the lines behind him the best have happened to be caught in his particular bundle. That super-intelligent and valuable mongrel dog of yours is a hybrid—the explosion caused by the meeting of the alien cells has resulted in good characteristics from all the respectable families behind him and a little saving grace of original sin from the gardener's dog!

In my work with plants I deliberately crossed different individuals and varieties. This is an operation that looks simple, but whether you get results

or not depends on your gift and practice and hand and eye. I like the old story about the great artist who was asked with what he mixed his paints to get such marvellous results, and who answered, "I mix them with brains, madam!" He didn't mean brains, precisely; he meant his own gift for colour and for its application to the canvas. Pollenization can be learned by any one, but only a few have the instinct that gets results. That is no credit to them—it is just given them, like red hair, or Edison's genius for chemistry and physics, or a good cook's pie-crust. This hybridization was done in Nature's gardens by the insects, the birds, the winds, and so on; in the plant-experimenter's grounds it is done by hand. Nothing left to chance or occasion, but all planned and timed and regulated. There is the first step in plant development.

The second step is selection.

Nature selected by a law of the survival of the fittest; that is, inherent fitness—the fitness of the plant to stand up under a new or changed environment. It was the plant's business, and had little or nothing to do with what man would consider, from his standpoint, the *improvement* of the plant. There is a kind of grass that grows on the Pacific Coast that shoots up tall and straight in protected spots, which is its natural home. Seeds were carried out along the seashore, though, where the wind blows hard and constantly. The grass had to accommodate itself to this new environment; many of the plants died—thousands—maybe hundreds of thousands. But those that bent themselves to the wind and survived put a new quality or tendency into their seed; in generations the pull of heredity to make the grass tall and straight had been overcome to such an extent that the grass was dwarfed and almost crept along the ground. The environment had changed the nature of the plant, and now we find two kinds of grass, of precisely the same original

strain, yet so different as to be almost unrecognizable as the same variety. Plant a seed from the tall brother along the shore and it will almost certainly be killed by the wind. Plant one of the dwarfs in a protected spot and it will continue to grow dwarfed for some generations, if it survives. It might not live, though, because the soil that had once been its home, or the particular temperature or moisture conditions that favoured its brother, might not be suitable for it in its new character.

That is selection by the law of the survival of the fit to survive. The victor in this struggle—this competition for life—might or might not be a plant more beautiful or more useful to man; it would only be the plant which had succeeded in adapting itself for its own benefit. I availed myself of this natural process—this law—in making my selections, only, instead of selecting by means of deadly environmental competition, I selected with a knife, or a hoe, or a spade and a bonfire.

Hugo de Vries, the great Dutch botanist, was very much interested in this wholesale method of mine, and in a book which he wrote on his theory of Mutation he commented on it in these words :—

"One very illustrative example of Luther Burbank's methods must suffice to convey an idea of the work necessary to produce a new race of superlative excellency. Forty thousand blackberry and raspberry hybrids were produced and grown until the fruit matured. Then from the whole lot a single variety was chosen as the best. It is now known under the name of 'Paradox.' All others were uprooted with their crop of ripening berries, heaped up into a pile twelve feet wide, fourteen feet high, and twenty-two feet long, and burned. Nothing remains of that expensive and lengthy experiment, except the one parent-plant of the new variety."

The second step—selection—is taken at different stages in the development of the plant, depending on what I am seeking to attain. There is nothing

like this sort of selection, as practised by the plant developer, in any other line of work I can call to mind. Breeders of fine animals, horses and cows and swine and sheep, and so on, come the ne to it. But they are looking for one or two qualities, whereas I must look for many—and must stay with it until I get them. The horseman wants strength or speed or a high-headed horse or a show horse or a gaited horse; the cattle-breeder may want a big milker or a big cream producer or a big beef strain, and that is about all he can expect to achieve.

But I start by wanting good form, size, spread of leaves or branches, and general appearance and sturdiness in all my plants, whether an amaryllis or a walnut tree; after that I may want a heavy bearer or a bearer of a few large blossoms, I may want fragrance, or may want colour, I may want a thin-skinned fruit, or a fine cooking fruit, or a good shipper or keeper. I have almost limitless needs in my work, and some plants have to be taught or trained or bred to give me one simple new characteristic, and others to give me a dozen. So you can see that I have to select and re-select again.

We must not overlook, here, another sort of selection that goes on before and after the selection as between two or two thousand individual plants or trees for the sake of getting a desired variety. This perpetual selection—this watchfulness and caution and care in seeing and acting on the difference between grades or qualities—begins in many cases with the seed, when one must sift the chaff from the wheat, the even, well-developed kernels from the irregular or faulty, those that are too small or too large, those that are scarred or bruised, and so on. In some cases, again, the germinating sprouts show differences, and those that would be a waste of time or garden space must come out. The plant develops, and again the weaklings or the awkward ones or the misformed ones must be eliminated. So it

goes on—selecting, selecting, selecting, first to see that your raw materials are the best possible, and then, when the time comes, to choose as between individuals, with an eye single to the purpose with which the whole experiment was begun.

It is when the time arrives for this selection for qualities sought in the plant or tree that almost any one would like my job. For then a thousand shades and variations appear, a flower gives perfume that never had it before, another shows a variegated colour scheme, another has drooping petals for straight, or straight for drooping, or a vegetable astoundingly exhibits a new quality or flavour or some amazing trait never seen before by mortal eye. These unexpected variations I speak of are in addition to the ones for which I am looking and on which, especially in later years, I was able to plan fairly definitely. And if I am working with a fruit—and usually with the vegetables too—I may not start selecting at all till the fruit or vegetable is ripe. In that case there is quite a lot of fun and interest, not only for me but for the whole family, because we go right into the kitchen or to the dining-table with our products, and we preserve or cook or make jelly or soup or stew, and selection becomes a matter for palate and nose, or even for the stomach and the digestive processes, as well as one of eye and touch and æsthetic measurement.

It was in this instinct for selection that I was gifted. It was born in me, and I educated it and gave it experience, and have always kept myself attuned to it. I have particularly sensitive nerves—that accounts partly for my unusual success in selecting as between two apparently identical plants or flowers or trees or fruits. There is certain music I cannot listen to without pain—and I am not making a joke there! What I mean is that some notes and vibrations in music hurt me physically, and I have once or twice been forced to leave a room or a

hall where music was being played or sung—and beautifully too!—because the strains hurt me. I have always been sensitive to odours, so that I could detect them, pleasant or disagreeable, when they were so slight that no one about me was conscious of them. My sense of touch is almost as acute as that of Helen Keller, who visited me just a short time ago and with whom I could converse easily—more easily than most—because we were so nearly equally sensitive.

Probably there is more to it than merely this sensory response in me—it may be a sixth sense, it may be purely intuitive—but I know that even those who have worked with me longest and have been closest to me, learning my methods and watching me in the gardens, have been unable to duplicate what I have done as a mere matter of routine, and with no thought as to how I did it. Some of the men who have worked for me have developed into good, sound, original, and even clever and successful, plant developers. But as far as I have been able to observe they have not been able even to approach my own natural ability to choose between plants, and to choose, not one from a dozen, or a few here and there, but at wholesale—thousands of plants in a day out of tens of thousands growing in my experimental gardens.

Even close friends and observers have said what you, perhaps, are saying to yourself now; that is, that I was bound to be right part of the time, and that there is no way of telling how many poor selections I made through error nor how many perfect ones I caused to be destroyed. My friends were wrong, as you are. I make some mistakes, of course, but considering the number of plants I have selected in the course of sixty years as a plant-breeder, they are negligible. On the contrary, I will tell you a story, out of many such that are available, to show you how complete my gift is.

From the first it has been my practice to mark selected individual plants by tying on a strip of old white cloth; this means that that marked plant is sacred, and you would soon notice that the men working for me would give one of the "neckties," as we call them, a wide berth. Plants that I could see would add nothing to my experiment, by any possibility, came up at once, or else were marked by my making a line in the bed with the toe of my shoe so that the men could take them out later. This left, of the hundreds or thousands of plants concerned, a large number that were tolerated, not so much because they had individual merit—though they sometimes developed that, here and there—as because watching their progress might throw some light on the experiment. Now, when I had a very large project going on—a field or bed with thousands and thousands of varieties or individuals in it—I would have two or three of my helpers follow me, and I would simply drop the "neckties" on the superior plants or those suited to my purpose, and put a shoe-mark against the worthless ones, about as rapidly as a man could walk along, and the men would do the tying and spade out and burn the condemned plants.

I was engaged in selecting from some thirty-five thousand plum seedlings one day when my friend, the late Judge S. F. Leib of San José, drove in. I went on with my work, but I saw that he was concerned about the growing pile of young trees being heaped up to be burned, and sure enough it wasn't long before he stopped me.

"Burbank," he said, "I have the utmost confidence in you and I would believe anything you told me about your work, but I can't think that you are right in uprooting all those beautiful seedlings and sending them off to be destroyed. It looks like a shameful waste to me."

"Well, Judge," I said, "this selecting isn't being

done by guesswork, though I suppose it looks like it. Why don't you take half a dozen of those condemned trees and plant them down on your Santa Clara Valley place, and find out for yourself whether I am right or wrong?"

He said he would like to make the test, and for good measure I insisted on his taking also six of the seedlings I had selected as the best varieties. So we dug the trees up carefully, packed them, and shipped them to his home. I saw him once or twice a year at least, and sometimes oftener, and the test of the trees was mentioned occasionally, but it wasn't until the fifth year, when the trees had had a chance to develop and come into bearing, that he made his report.

"Burbank," he said then, "if any one had told me five years ago that selection could be done by a man almost at a trot, I would have said that he was crazy. I have been an orchardist for years, and I think I know something about horticulture and plant development, but what you have shown me beats anything I have ever heard of!"

Then he went on to admit that he had been wrong and that I had been right in every single case. He said that he had ordered his men to take out and burn all of the six trees I had condemned as seedlings, five years before, but that every one of the six I had chosen had proved perfect trees with beautiful, luscious, well-developed fruit and plenty of it. He was very fond of telling that story on himself, and he did a great deal, as he had done before that incident, to help me with my work and to give me confidence in myself and give other people confidence in me.

If you will stop a minute to consider, you will see that I had to be accurate in selecting, or I would have wasted half my time growing varieties and individuals that were useless to my experiments, or else I would have done what Judge Leib thought I was doing—thrown away or destroyed thousands of plants with possibilities. No; the fact is that I have

a gift for selection that I suppose very few men in the world have ever possessed in any line. It was a straight benefaction to me from my heredity, somewhere away back, and environment—my work and my need for a selective faculty—developed it, and education—experience and watchfulness and study—perfected and polished it. But to it I owe a large measure of my success, because it made possible the conducting of an enormous list of separate experiments, most of them done on a very broad scale; without it I could not have worked with so many kinds of plants nor done so many different things with so many different varieties and species.

Hard work, application, study, love of the task, the desire to cover a wide range, and the ability to learn from Nature and then to select accurately as between individuals of apparently identical character—these have been the basis of my achievement—these are the foundation stones of success in plant development and improvement, and it was these that have made it possible for me to give the world so many new creations in flowers and grains, fruits and vegetables, shrubs and trees and vines.

My original marketing of the Burbank potato won me no recognition from science, because it was merely the more or less fortuitous development of a new variety. You see, it was something as though a prospector had discovered a new gold-field; the geologists and mineralogists would know all about gold, and the mere addition of a new field wouldn't concern them much. But when I began to establish the fact that I could train old varieties in the plant world to new habits and possibilities, and could produce entirely new varieties with characteristics and values never known before, I was more like a man who has taken known metals and from them extracted radium. The moment I emerged as a scientific experimenter and investigator the scientists wanted to know more about me.

Very slowly, but surely, the word spread that there was a young fellow out in California who made claims about plant-breeding that had never been made by any living human being on this planet before—and not only that, but that he was showing his wares as proof. I began to get letters and inquiries about my work, and after a while I had a large number of contacts, faint or strong, indirect or immediate, with the world to which I was to belong from that time on—the world of science.

There were some other contacts being made at this time that proved in the long run to be of the utmost importance to me and to my work. They began with an idea I had that California seeds might be interesting and useful to foreign seedsmen; there were large and old firms scattered about Europe and England and down in Australia, and I wrote some of them offering seeds, and particularly California wild-flower seeds.

Much more quickly than might have been expected I built up a good business in this line; very few people know it, but the fact is that California wild-flowers and native plants have been transformed or developed into some of the favourite garden plants of England and the Continent. That I contributed something to this result is perfectly plain.

The work gave me much satisfaction and pleasure and some cash. It brought me into touch with the whole world of men interested in flowers and plants, not for the sake of their anatomy or leaf-structure or Latin names, but for the sake of their beauty and utility, and it was an inspiration to me to find everywhere men of high standing and well considered in their own lands working away at something like my own job.

V

My nursery business had gone ahead satisfactorily throughout the early eighties, but I began to discover that I could not carry the load of business and details it entailed, nor give the time necessary to seeing customers and talking to people about orders, with all that meant.

I found I had to fish or cut bait, as the saying is, and I decided to cut the bait. If I supplied the varieties and worked out the problems, there were plenty of people handy at selling: presently I disposed of half of the nursery business, and later got out of it entirely. I went at my work in the experimental grounds, and by 1893 I had a bombshell to explode.

It took the form of a catalogue, under date of June, 1893, and its title was *New Creations in Fruits and Flowers.* Inside the cover page I made the following announcement:—

"The fruits and flowers mentioned in this list, and to be mentioned in succeeding lists, are more than new in the ordinary sense in which the word is generally used; they are new creations, lately produced by scientific combinations of Nature's forces, guided by long, carefully conducted, and very expensive biological study. Let not those who read suppose that they were born without labour; they are not foundlings, but are exemplifications of the knowledge that the life forces of plants may be combined and guided to produce results not imagined by horticulturists who have given the matter little thought.

"Limitations once supposed to be real have proved to be only apparent barriers; and, as in any of the dark problems of Nature, the mental light of many ardent, persevering, faithful workers will make the old paths clear, and boundless new ones will appear by which the life forces are guided into endless useful and beautiful forms.

" We are now standing just at the gateway of scientific horticulture, only having taken a few steps in the measureless fields which will stretch out as we advance into the golden sunshine of a more complete knowledge of the forces which are to unfold all the graceful forms of garden beauty, and wealth of fruit and flowers, for the comfort and happiness of Earth's teeming millions."

Nowadays, when we are accustomed to picking up the daily paper and reading that some heroic flyer has just crossed over the North Pole, or that a biologist we never heard of has found a new vitamin, or that a machine has been invented that will transform the business of keeping food iced in our homes, we might not be more than passingly interested in the announcement that a horticulturist had created a new kind of pear that would put all the known pears into the shade; in 1893 things were not moving quite so fast, and a claim like mine made quite a loud noise in the sedate and mannerly period when the White House was occupied by President Cleveland and when Queen Victoria still had several years left of her long reign.

Prior to this I had sold several new varieties to the public or through big nurserymen, but here was a wholesale bulletin, proposing to dispose of almost a hundred absolutely new plants, flowers, berries, and trees, together with complete rights and control, in each case, so that the buyer could be sure that he would have no competition. The list began with the hybrid walnut, which I called the " Paradox " because it was a paradox that a hardwood lumber tree could be produced to grow as fast as the most rapid-growing and short-lived variety. The catalogue said of this tree:

" The first and one of the most interesting of the hybrids produced among walnuts. Budded trees six years of age are fully twice as large, broad, and tall as Black Walnuts at ten or Persian Walnuts at twenty years of age. The leaves, which are from two feet to a

full yard in length, are clean-cut, glossy, bright green, and have a surpassing sweet odour resembling that of fragrant apples and as powerful and peculiar as that of roses and lilies."

They scarcely believed that one—but they went away convinced if they ever saw it!

There were four new quinces, ten new plums and prunes, a large list of berries, a number of flowers, including the first double gladiolus ever known, with flowers closely arranged around the spike like a hyacinth, and my "Silver Lining" Poppy, which, instead of being crimson and black on the inside, is a glistening silvery white, the outside retaining the same brilliant crimson as its forebears. Finally the booklet was completed with an offering of vegetables of new variety and productivity. Near the end of the book, too, I find there was a picture of the blossoms of the cross with which I was then experimenting between the apricot and the plum—the first public reference, I guess, that was ever made to my plumcot.

In a statement at the end of the book I set down my whole theory of plant development, summing up all my knowledge and experience in a few sentences, and laying down the law in these words:—

"There is no possible room for doubt that every form of plant life existing on this earth is now being and has always been modified, more or less, by its surroundings, and often rapidly and permanently changed, never to return to the old form.

"When man takes advantage of these facts, and changes all the conditions, giving abundance of room for expansion and growth, extra cultivation and a superabundance of the various chemical elements in the most assimilable form, with generous light and heat, great changes sooner or later occur according to the susceptibility of the subject; and when, added to all these combined governing forces, we employ the other potent forces of combination and selection of the best combinations, the power to improve our useful and ornamental plants is limitless."

It might be a good thing for you to have in your minds, along about here somewhere, that there is a great controversy among scientific people concerning the answer to this question :—

" Do our changing racial and individual traits, observable throughout the whole realm of life, both past and present, come to us by inheritance—are the seeds all contained in the minute organisms from which life springs, or, on the contrary, do we acquire new characteristics, from our situation or necessities —our environment—and pass those new tendencies or abilities or powers on to our children ? "

The question is whether all changes, which we notice in successive ages of life development, are traceable to heredity alone or whether we can " inherit acquired characteristics." The man who believes the former says that the loyalty, fidelity, and good nature of a fine police dog were contained somewhere, perhaps only potentially and not at all developed, in the wolf from which that police dog finally sprang. The man who believes that acquired characteristics can be and are inherited maintains instead that a pair of savage wolves can be caught and somewhat tamed; that their puppies can be raised in domestication and made a trifle less savage and treacherous; that after generations and generations the characteristics of gentleness and good nature and fidelity to a master become so impressed on the succeeding generations that there emerges finally a police dog which is only distantly like the original wolf parents, having *acquired* so many new characteristics and passed them on, bit by bit, in the blood-stream, that the police dog is practically a new species of animal.

There is a great deal more to this controversy than my bare outline even suggests, but perhaps this statement is enough to explain the fundamental proposition disputed and to make clear what I am going to say in connection with my claim that I had produced " New Creations in Fruits and Flowers."

I myself have proved, beyond question or doubt, that new characteristics, foreign to anything in the heredity of the plants involved, can be and are so impressed in succeeding generations by my process of repetition, repetition, repetition, over and over and over again, and always for the same effect and in the same direction, and there comes out in the end through selection a new and distinct plant result. It was this conviction, in the face of the controversy that I refer to, that is expressed in the first paragraph of the summary I have given above. I stated that " plant life is now being and always has been modified more or less by its surroundings (environment) and often rapidly and permanently changed, never to return to the old form." This was strong medicine for the straight-heredity theorists, and Balm of Gilead to those who believed with me. I am going on in a moment to tell you something of the processes I employed. In the meantime the catalogue had another far-reaching effect that was sensational and unheard of before. This was the amazement and indignation with which many orthodox people received the claim of a man to " new creations."

I could see, and did see, that the term would be examined critically, but it had not occurred to me that it would be considered blasphemous. Not that it would have caused me to use other words if I had foreseen the storm; I have never been one to consider how my utterances would be received by others, so long as I felt convinced that what I said was sound, scientific, and accurate. I didn't think much about the matter from this viewpoint, to tell the truth, because I was so absorbed in the importance of my work and the necessity for impressing horticulturists with the significance of what I had accomplished. I spoke up and said my say and then I went back to my job.

It presently seemed possible that I was going to have a good deal of difficulty staying there. A per-

fect storm arose, in the heat and wind of which I was called a good many names stronger than blasphemer; I was preached about, talked at, written, telegraphed, scolded, abused, and even vilified: the more extreme of my critics said that I was setting myself up as a competitor of Omnipotence, and the mildest of them called me a falsifier. One preacher inveigled me into his church, had me seated in a front pew, and then worked up a trap for me by which I had to say just what I believed as to the truth of natural laws behind all life and what I disbelieved as to the truth of metaphysical and superstitious theories concerning creation. When he had me, as he thought, in a fine bag, with the drawstrings pulled, he proceeded to berate me in good old orthodox style, and ended by offering a prayer for my awakening. Of course I had neither thought nor said anything either impious or blasphemous, unless it is impious and blasphemous to work with Nature, utilize her laws, direct her work, apply intelligence to plastic forms, and then claim a victory in getting useful and beautiful results. But it was lively while it lasted!

In plant architecture, if I may coin an expression, the main thing that strikes me is that you have to wait for some of your materials to be arranged by Nature. Wild seeds are your raw material—wild seeds or cuttings from native trees or vines or shrubs: they are as wary and timid and hard to tame as wild animals, and also, as with wild animals, they are very likely to surprise you with traits and dispositions and tendencies you haven't counted on at all, so that you must be continually on your guard. Well, these raw materials, and others you or some one before you has developed from them, must grow to your needs, while others you can arrange. You have certain materials at hand, but you have to wait for others—they partially arrange themselves. In ordinary architecture you merely shuffle them.

There is a good example of this in setting cement. You bring all your materials for the house or the business block or the public building together and plan your arrangement of them. You shuffle your brickwork and your woodwork and your doors and windows and your porches and balconies, and so on, to get them into the right places, so that your final proportions and balance and mass will be right, but with all this, as soon as you start working, you have to wait for your cement to set before you can go on with your fine design. That is the way it is—that is precisely the way it is—with the work of the plant-developer.

Some of my most important and valuable work has been with the plum. When I began, the plum was small, usually acid, generally unfit for shipping, often with a large stone, and sold in America in a limited number of varieties. I wanted to get a plum that would ship, a plum that would dry well—what we call a prune, because the French call it that—a plum that would be beautiful and delicious, a plum that would be large, a plum for canning, a plum with a small pit, or none at all, and so on. My designs were pretty carefully worked out.

For instance, as regards the shipping plum. The plum developed to be picked from the tree and eaten right there, or within a few hours in the house, was quite a different thing from the plum that could be picked, packed, shipped, delivered maybe thousands of miles away, unpacked, sold, carried home, and finally eaten fresh. You can see that. The variety for home consumption could be soft and juicy the minute it was ripe; the shipping plum had to be soft and juicy and delicious after it had travelled half as far as did Nelly Bly. And this couldn't be acquired by accident or chance—it had to be studied and the specifications pretty carefully written.

For shipping it was necessary to have the trees bring their fruit to the proper stage of ripeness all at

once. It would never pay an orchardist to go over and over his orchard, picking the plums that were ready and letting the others hang. Why, a man would starve to death with that sort of an orchard —his pickers would cost him more than his orchard was worth! You should be able to go right through the orchard, when the time came, and clean it up and cash in on the harvest.

Now you have a notion as to the ground-plan of just one plum. It was necessary to find parent stock that would contribute the proper blood-strains—one for firmness of flesh and juiciness, one, perhaps, for sturdiness in the tree, one for that characteristic of coming to perfection all at once. It was a case of choosing my materials carefully, then, by crossing, to get the beginnings of the building. But after that the scaffolding had to come away. I had to select and select and select for the qualities I was after, and it was a long and expensive job, because a plum tree is not like some flowers—it will not take root and grow and bud and blossom and bear fruit all in a month or two, or even in several years; the short cut I used, of course, was to bud well-established, sturdy trees with buds from the crossed seedlings I produced. Many men had worked at this, more or less; here is where I used the wholesale plan. Instead of trying one or two buds for crossing for one or two results, or growing half a dozen seedlings, I would choose twenty varieties, grow fifty thousand seedlings, and bud hundreds of buds. More than that, I made my old parent trees work: sometimes I would bud as high as three hundred buds into one tree. It was new. It was startling to many. But it hurried Nature along. It brought results.

But not all at once, even then. By no means. Take the effort to get a stoneless plum. Remember that man can only utilize Nature's methods—he cannot alter or amend them. The man can plan the work, but he can't induce the plum to drop its stone

all right away, even though man knows that, for his purposes, the stone is useless to the plum. You see, the plum has considered the stone important—about its most important part—through thousands and thousands of years, while man may have had the idea of dropping the stone for a few months. The wolf cannot be tamed in a minute, because he has ten thousand years behind him that put a premium on his wildness.

VI

A MAGAZINE writer who should have known better once put at the head of a story of my work and methods the title: "Burbank versus Nature." I can't remember anything that made me quite so hot under the collar as that caption. It was something like writing a treatise called: "Wilbur and Orville Wright versus the Law of Gravitation."

Because there never was a man lived on this planet who had more respect for Nature, who studied her rules and her system more diligently, nor whose work depended more on an understanding application of her laws. The newspaper headline writers long ago dubbed me "The Plant Wizard," and perhaps a good deal of nonsense has been written, at one time or another, along that general line. There was nothing mysterious, occult, magic, or metaphysical about my work—not in the slightest degree. I was Nature's pupil; I did manage to find ways to speed up her results, but wherever one of my experiments succeeded it was because I followed the rules, and where one failed, nine chances in ten it was because I overlooked some law or encountered a new section I hadn't committed to memory before.

Going to school to Nature, from my earliest days, I learned, first of all, that it was possible to direct the habits and tendencies of plants towards a greater usefulness and delight for mankind and also to release in them potentialities that were desirable from man's viewpoint. I have surprised many people by finding a striking parallel between plant and animal life; many have thought I was speaking figuratively when I have compared the education of plants to the education of children and, the other way about, have said that we

can learn how to teach our children to their best advantage by observing carefully the laws Nature lays down for the development of plants and plant life.

There is, of course, a sensational similarity between the course of every kind and degree of life. Fundamentally the laws governing cells or even crystals, are the same as those governing plant life, animal life, human life. All cells are made up of protoplasm which, in turn, is made up, as I have said before, of a little contribution from everything in Nature. How is it possible, then, that these cells, apparently of the same material and constituent elements, may grow into a flea or a buzzard, a crane or a horse, a pansy or a redwood tree, a bit of living scum on a stagnant stream or a beautiful child?

Well, a good figure there is the alphabet. There are twenty-six letters, and only part of them extensively used, yet there are something like half a million terms or words made up of those few letters—a handful. How? By different combinations. That is all. Some of the combinations are as violently and widely different as a toadstool and a lion are different—the first word in my dictionary as aabec and the last is zyxomma. Other words have a great similarity—benediction, benefaction, benefit, and benevolent, for example. Just a different train of cars in each case, but all headed generally in the same direction. So, in living things, many of the organisms made up of cells have so much in common that we group them together as distinct families, such as the human family, with white men and red men and black men, Saxons and Latins and Negroes and Chinese; but all of them with eyes and ears and mouths and legs and arms, walking erect and being given the power to feel and reason and think both backwards and forwards, and able to use their thumbs—which, if you will consider it a minute, you will find is one of the most remarkable differences between man and the other animals, and the one that makes possible most of man's handiwork, and the

lack of which prevents the beasts from doing more than the most elemental construction work.

The thing that binds all life together, then, is the cell from which all life springs and of which all life is made up. You cannot study plants without learning something about men, nor study men without getting ideas about animals and fish and plants. Comparatively few scientists speak in terms intelligible to the layman: they are specialists, concerned with some particular phase or form of life, or with determining laws governing particular activities, developments, or manifestations of life. The naturalist, on the other hand, no matter how scientific, makes himself understood by all because he deals with a manifestation of life in which all are interested and the language of which all the world speaks. Plants and animals, forests and mountains, flowers and children, are to be studied by any one; the naturalist only adds to the layman's understanding a more extensive knowledge of the scientific basis for those phenomena, actions and reactions, habits and tendencies, mysteries and marvels, in which we are all interested and with which we are all more or less acquainted.

I am hoping that I shall therefore be able to make myself as clear in these papers as though I were writing of salesmanship or how to drive an automobile—I want to talk the language of every day. In that tongue let us consider for a little this subject of Going to School to Nature.

I have told in an earlier chapter how my first helpful contact with Nature was when I came on a green spot of lush vegetation in the middle of a timberpiece in New England in the dead of winter. That showed me that Nature had a provision by which plants could adjust themselves to an unusual or changed environment, and could not only thrive, but could pass on to succeeding generations this acquired power. In my earlier days as a truck-gardener in Lunenburg I had forced corn to early

harvest by planting the seed in hotbeds and crowding into the growing plant, when it was removed to the field, the food I knew it needed. This showed me that plants were amenable to improvement and speeding up, or to any other desired development, by the process of catering to their needs—by using the intelligence of man to take advantage of the general laws of life.

Those are examples of the lessons I learned in my chosen school very early. They were merely a suggestion of the infinite storehouse of information and knowledge Nature has for her children. As I went on with my work, instead of finding out everything and taking my degree and settling back with the feeling that I knew all that Nature had to teach, I discovered that everything I learned opened up new avenues for my ignorance; that every fact had a whole family of cousin-facts around it.

I began with the cell—the fundamental unit of life: it was apparent from all I saw that the cell was influenced by environment, that those influences, if they persisted long enough—repetition, repetition, repetition—entered into the heredity, and that this heredity was the factor I had most to deal with in training plants to bend themselves to man's greater good. Because it was the strongest factor and the deepest rooted; it was the one it had taken Nature generations and maybe centuries or ages to fix, and there was going to be no teaching these old dogs of the vegetable world the new tricks I had in mind for them to perform unless I used diligence, patience, and a knowledge of Nature's own processes.

In the potato I had had a striking lesson of the amazing variations that can come, suddenly and without any apparent explanation, in the midst of the life of a common, unornamental, unsensational, everyday plant: I had proved that those variations could, by selection, be weeded out until the best was obtained. In other experiments, numerous and

varied, I went farther and demonstrated that variations could be induced in plants by cross-fertilization. There was my starting-point: the law that makes variations possible, and my ability to select from among the variations in order to get and fix the qualities desired.

It is one thing to know how a mathematical problem, for instance, is to be worked, and another to gather, place, and align all of a large number of factors in order to be ready for the actual figuring: it was so with my beginning in plant-breeding. I have never left off studying; I have never felt that I came anywhere near mastering my subject; the learning was the greatest pleasure of my life, and still is, because Nature is not only a wise teacher, she also knows how to make her subjects fascinating, interesting, and full of marvel and beauty.

As I have said before, the raw material of the plant-developer is the seed of the wild plant. This is true whether it is seed sought for and studied and sown for a definite or experimental purpose, as in my work, or is a seed brought home by an African bushman with a vague thought that it may add something to his store of edible plants. The wild growth of the world is the original parent stem—of all growth, and to the flowers and shrubs and vines and trees of our hills and mountains, prairies and deserts and plains, we turn for all our new sources of beauty and utility for our gardens and fields.

There was nothing so likely to attract the attention of the newcomer to California as the California poppy, that glorious golden-yellow flower that mantles all our hills and plains in the spring and that, with the purple lupin, goes to make landscapes incomparable in beauty—a revelation of the perfection with which Nature paints her scenes when she has a mind to exert herself a little. In the spring following my arrival in California I thought I should go mad with the excitement of watching those splendid carpets unroll on the

hills around Santa Rosa; one would have supposed that I would weary of the poppies after a while, but I never have and never will. They were my first inspiration and delight, and from them I learned many of my most important early

I observed among other things that there was a wide variation in the poppy—both as between separate fields and in different localities, and also in the same fields, where there was more or less variation in size, colour, and even, in some cases, in general formation. I found that some botanists classified the eschscholtzia (named for Johann Friedrich Eschscholtz, a German physician and naturalist who lived in the early part of the last century) as one single species, whereas others find twelve, Greene 112, and Fedde 123. They are all debating the matter, and from laboratory examination and analysis they have a right to be uncertain. But as a matter of fact the explanation is extremely simple. The California poppy is in a transitional stage—it has not yet found and fixed itself. To my way of thinking all the eschscholtzias that are actually California poppies are of the same species—a great family of brothers and sisters and cousins having a family resemblance, but with none of its characteristics definitely fixed. It is probably a young plant, botanically speaking, and hasn't found itself.

On the coast, for instance, the California poppy generally has a very large blossom—a different type from the inland poppy. As you come inland into the big valleys you find the blossoms growing darker in colour, smaller, and more variable, probably from having migrated from different sides of the valley. You cross the valley, noting variations of size and height, then, as you come up into the eastern foothills again, you get plants small in size and somewhat smaller in blossom. It is when you begin to climb towards the mountains themselves that the greatest change is observable. No wonder the botan-

ists call this mountain poppy a different species; it bears a small, flat blossom, the plants hug the ground closely, and any one who did not know better would certainly begin thinking up a new name for a new species!

It took a long time, I found, to take this mountain poppy back to big blossoms and plants again, even with the most careful selection; it would take perhaps longer to get the valley poppies dwarfed down to stand the high altitudes. But it could be done, for I have done the same thing with other plants, and have impressed and impressed and impressed them with what I was working for so repeatedly and so patiently and so long that, in the end, they would capitulate and give in and go to work for me as I wanted them to work.

A most interesting study of these variations in the poppy are found in a neighbourhood north of Santa Rosa, between the coast and the mountains, where the soil varies in fifty feet in any given direction and where the climate is variable in a half-mile. The altitude is fairly high, yet it is not mountain country; on the other hand, the place cannot be called lowland or a valley. There is a good deal of moisture, and so on. Well the poor poppy has a hard time to decide there what it is going to be, so it compromises by being a little of everything!

That is what I mean. The difference in environment gave me there a more pliable plant—a plant finely balanced—teetering on the edge, you might say, and able to swing this way or that with far less pressure from me than any plant, poppy or other, that had grown set in its ways. Nature, you see, helps the plant-experimenter, more often than you expect and with a more generous hand, especially after you have the plant experiment started in the right direction and have got rid of a lot of old, persistent, bigoted habits. In the case of these variegated poppies the unusual environment had already caused

the plants to shake off many of their fixed ways, and they were just ripe for change.

Californian plants, as a matter of fact, have so many different climates, altitudes, moisture conditions, growing seasons, and so on, to deal with that, as has been frequently pointed out to me by great botanists, they show more variations in themselves than plants almost anywhere in the world. Also, of course, this fact gave me another advantage—namely, that I could grow in my gardens plants from all over the world: a larger percentage of the known plants, perhaps, than most plant experimenters could study and work with. There are many—thousands and thousands—that will not live, even in California, but my field was broader than it would have been pretty nearly anywhere else.

Here, then, was one of my lessons from Nature—that different environments produce plants of the same family that are so widely different that even the botanists want to put them into separate classifications, and yet they are the same plants identically. Their only differences were the pure result of environment, and expressed themselves physically, in varying shades, shapes, sizes, and so on, without being in the least different in their actual make-up or heredity. It is a crystal-clear illustration of the natural law which, intelligently applied by man, with a definite purpose in his mind, would eventuate in new forms—in what I call *new creations*.

The poppy is an example of the variations caused by varying climatic, moisture, and soil conditions, and by altitude; there are other variations in plants that are due to environmental conditions which modify the plant or its structure or its habits to fit it to receive help from friendly surroundings and to ward off injury from unfriendly ones. Forget everything, for example, but the leaves of plants and trees. Notice those in your garden or a park or along the streets, or in the country. No two just alike! So

different in shape and form and thickness and texture and length and position on the tree or the plant or the twig or the stalk as hardly to be the same sort of thing. Why?

Always there is a cause, if not in the present history of the plant, then sometime in its past history. Nothing about a plant or an animal or a human being exists by chance—Nature may select by chance or she may develop an unexpected and apparently accidental characteristic, but if you look far enough you will always find that everything about a plant or an animal is the result of the working of some clear law. And so there is a cause for the leaf—its shape and form and texture, and I know of nothing more interesting than to speculate on that cause and to determine it if you can.

The needle-like leaf of the pine, for example, is the result of the need the pine had for sunshine bathing it, in the comparatively short season that it lives in the sun, and of the need the tree had to shed the great loads of snow that fall on it in winter-time. If it had had a leaf like the banana palm, how long would the pine have lasted under a two-foot fall of snow? Also it is a tough leaf—take two or three green needles in your hand and twist and pull them and you will see they will stand pretty rough usage. Well, there is the leaf to bear up under driving wind and pelting rain and heavy snow and cold, and even the intense midsummer heat of the mountain home of the pine.

The banana leaf is exactly opposite—broad, tender, casting a great shade, catching whatever moisture there is for it to catch, and never having to bear up against wind or snow. Go on to the desert and there examine the leaves of the native growth. You could not expect to find a thin, delicate leaf on any desert that had been desert long, because of the sandstorms, the terrific heat, and the lack of moisture. So you find tough, pachydermic skin, like that of the elephant,

or else covered with fine hairs or some substance to protect it. What we call the ice-plant, that grows along the coasts, has a tough skin on its leaves, and it grows low and sprawling because of the wind and the sharp sand blown against it by the wind. There is not a single plant or tree that does not have an absorbing story in its leaf-structure, if you will take the pains to study it.

Now, there is something from Nature's book worth learning! The rose-bush is covered with thorns, the porcupine with spines, the cactus with poison darts—and all for the same purpose: defence. The strawberry hides under its broad leaves, the rabbit under a bush, and both because they have no other protection except to avoid being seen by enemies. The fruit-pit, bearing the seed, it is very difficult to break into; the soles of a man's feet are tough and of thickened skin; in each case the reason is originally that the seed must be housed against destruction by birds, the feet armoured against thorns and pebbles and a nail in the shoe. Do you think these natural provisions are the result of chance?

Not at all. There is a dispute among scientists as to the exact method by which these provisions are ultimately bred into the individual, but there is no dispute as to the purpose. It is to preserve life and to make it possible for that life to re-create itself in offspring—the two cardinal laws of being in the world. And you can easily apply the law in more ways than one in your everyday existence. Taking a leaf from Nature's book, you can teach yourself to be superior to exterior aggravations, troubles, and annoyances; you can build yourself an armour against sickness and failure; you can adjust yourself to your environment, or, if you find that impossible or undesirable, you can seek a new environment and adapt yourself to that, for your own ends. Mind may or may not be everything and matter nothing—I can hardly subscribe to that doctrine!—but there is no

question that Mind, trained, directed, educated, can, on the one hand, school and guide the body, and, on the other, use or discard, capitalize or ignore, material things pressing upon it—can, in short, adjust itself to environment!

VII

In the previous chapter I referred to the dispute among scientists as to the procedure by which adjustments are made by plants and animals so that new powers and abilities, and even new muscles, members, or whole organs, come into being and are incorporated in the heredity of that variety, or, on the other hand, are slowly dropped from that heredity and cease to be known there. For example, the heron must have been once a short-legged bird; the horse was once an animal as big as a dog and had toes; man's ancient ancestors were from the same parent stock as apes and, in the dim ages of the past, had a tail and swung from trees. What lengthened those legs, or changed the horse's toes to a hard but springy hoof, or curtailed your friends and acquaintances?

There is a very interesting theory, supported by some of the facts before us and apparently denied by others, that is called the theory of "use and disuse"; that theory holds that when need creates a certain kind of leaf, for instance, in a plant, that certain kind of leaf persists as long as the need for it exists, that is, as long as it is *used*; it goes on to the corollary proposition that, if the need ceases to exist and that certain kind of leaf is no longer used, it will eventually cease to exist and the plant will have another kind of leaf.

This theory of "use and disuse" leads us to another theory of biologists—namely, that need can create a function in an animal or a plant, and that function can and does create an organ to take care of it. As an illustration we may take the time when certain sea-animals came out to live on the land, as they did

centuries and centuries ago. In the sea they need gills to breathe through and fins to swim with. On land they breathed without gills; they swam no longer, but instead they walked, and needed legs and feet, and their fins were useless to them. The *need* of legs, these theorists maintain, was apparent before the actual legs were; the need created the *function* of walking; the function of walking brought about the *structure* with which to walk—that is, the legs. You will find scientists who deny this theory, but my work demonstrated its truth to me beyond any questioning or doubt.

You can put it down as a very good rule, the structural always follows the functional; in other words, the necessity of a thing is exhibited as functional and afterwards the structure arises. Structure—the shape of the pine leaf, for instance—is built up by function—the need to shed snow, in the pine leaf, and to stand wind, let us say; and the function or power to shed snow is upheld by structure—that is, the long, needle-shaped pine leaf. In plants almost all their functions are taken care of by temporary structures: if the need of the structure disappears, the structure disappears too. It is like the staging or scaffolding on a building—it is absolutely essential to the process of erection, but once the building is standing firmly the scaffolding comes down and can be used in the interior of the building somewhere, perhaps. Often, as a matter of fact, the plant actually does use its staging for some other purpose, and always the strength that went into the staging goes later into the plant.

Let us take an example of this need bringing about a function, and function bringing about a structure or organ or ability to meet the necessities of the case. Here is a man. He is a fighter—a warrior—pugnacious, because he once lived in tribes and had to fight for food and for a wife and for his chance—had to fight for elbow-room, even. He lived that way for centuries. Civilization came, we invented policemen

to guard us against thieves, we trained dogs to protect us against tramps, we instituted laws to protect us against greedy or turbulent or dishonest neighbours, and we built up armies and navies to prevent other tribes from coming in and enslaving us.

The fighting spirit in man became almost unnecessary, so that most of us now live peaceably and quietly, and we don't go out and knock a man down to take his beef away from him, or his wheat or his wool—we go into a store and pay him for those things. The strength and nervous force and skill required for fighting in the ages gone are now directed to other needs we have, and we build ships and skyscrapers, we write books and poems, we invent aeroplanes and discover vitamins, and breed plants.

Here is a plant—the horse-radish. Originally it put a lot of its strength into seed—and do not forget that the growing of seed takes a tremendous amount of sap and food and vital energy from every plant—but people more and more raised it from tubers, so that finally the horse-radish practically ceased to produce seed. That is true also of the potato; it is only once in a long time that you find a potato seed-ball. There are plenty of examples, too, among plants that were originally climbers. They had to climb up to get sun or air or rain, but after a while they grew strong, were able to take care of themselves, and they lost the habit of climbing, and eventually lost the ability to climb.

"You see, when you force a plant, or when Nature or necessity forces a plant, to do something that is unusual or difficult for it to do, it will do it, if it can, but the effort costs it too much. It takes more vital force for a woman to run to catch a train than she can afford to spend; after a while perhaps she decides she will take a later train—or else she starts early, so she will make connections without running herself half to death! The plant finds it takes too much strength to adjust itself to an unfriendly environment

with just the old equipment it started with—equipment that it had in an earlier and more friendly environment. There is the need, then there is the function, then, after a time, the plant builds up a structure to perform that function and take care of that need automatically. There is the same thing again that I have spoken of so often in my work: repetition, repetition, repetition, of need eventually gives the plant a new machinery for taking care of the need, and the new machinery becomes a part of the regular equipment of the plant's factory, and that improved equipment becomes a part of the plant's heredity.

Precisely the same thing occurs in humans. A great many teachers and parents use repetition, repetition, repetition, in training children; though they may not know it, they are fixing in those children something that, if it goes on for enough generations, will become a part of the child, and will be passed on by that child to its children. It is not necessarily the words that fix themselves in the minds of children so much as circumstances and incidents and experience that fix impressions in the mind. Repetition makes those impressions stronger and stronger, the human mind reacts to these impressions with a new function or power to take care of the new impressions or needs or desires, the new function or power builds up a structure, perhaps in the brain, so that finally the structure takes care of the need automatically, and the structure saves so much by this special adaptability to a special use, that it becomes transmissible. That is where our heredities come from—from experiences and needs and desires and habits long and long known to us and long and long met with our best efforts. Heredity is nothing but stored environment—the sum of all our past environments. I have said that before: I cannot say it too often.

There was another of the great lessons I learned in Nature's school. When I went to work with a

plant I first considered its heredity. I knew that it was used to a certain climate, a certain cultural method, a certain soil, and that it was in the habit of delivering a certain sort of crop for value received. I learned how strong heredity is in all life, and that you could not hope to overcome an old heredity with new influences in a short time unless by a short-cut method that would take advantage of that old heredity rather than attempt to turn it suddenly into a new channel.

I had to be sure of my groundwork—the plant's heredity—before I could make a start with improving it, or experimenting with it. In the first place, heredity governs more strictly as regards the climate than as regards any other thing in a plant or tree. Lots of time has been wasted trying to make cold-country plants adapt themselves to hot countries, and plants from the tropics thrive in a temperate or colder zone. There is one possible way to overcome this hereditary obstinacy, and that is to take a plant from a hot country, find a cousin of the plant that grows in a cold country, and cross them, and from the cross you would get seedlings, one out of a thousand of which might give you the desired adaptability to the new climate. But the problem is to find relatives from common origins that have become this much scattered over the world.

You know by its heredity pretty much where any fruit tree will thrive, if it is not too much crossed and its heredity jumbled. So long as you can trace out its main heredity you are all right. The Concord grape is an Eastern American and thrives over a good part of the United States and the southern Canadian lands. The European grapes were originally Asiatic; they have been longer under cultivation and their ways are more fixed and set, therefore they demand certain things of their climate and soil, and do better in semi-tropical climates. In my work I have studied such factors so long that I can tell more easily about the life-story of a plant, even a stranger

to me, if I know where it comes from, than most people can, but the study is interesting enough for any one, and can take you all around the globe, almost, in your own garden.

Now, here is another thing that I learned going to Nature's school: that plants have as many qualities and characteristics and peculiarities, pretty nearly, as a human being, and your handling of them has to be determined by the length of time those qualities, characteristics, or peculiarities have been in the heredity of the individual plant. Let me go into that a little carefully.

All living things, as I see it, have three powers inherent in them: the power to fight for their self-preservation, the power to re-create themselves in progeny, whether by spawning, seeding, breeding, or the mating of humans, and finally—and this is a different way of putting it from that you will find generally in the text-books!—the power to vary.

Throughout all Nature the most cunning and sometimes intricate machinery is provided by the individual itself, or by Nature for the individual, if you please, through which it can protect itself from its enemies and take advantage of the help of its friends. The lion is powerful enough to defend himself; the tortoise is slow and helpless, so he has a thick shell to armour him against his foes. The eagle is swift and strong; the rabbit can dart into a low covert, where he finds asylum. The blackberry grows in high, open, showy fashion, where any marauder can rob it of its fruits, which contain its seeds, so it was furnished with a multitude of sharp thorns; the strawberry, on the other hand, grows low, hides its fruits with its leaves, and is unostentatious and modest enough to escape any but the sharpest eyes. And so through all Nature.

That is the power to preserve itself, *in the individual.*

Of what use self-preservation to the whole scheme of things, though, unless the species could be carried

on? Nature does not heed nor give thought to the individual; she is ruthless and even, we are compelled to think, sometimes cruel and merciless, as far as the single animal or plant is concerned, but she seems to be intent on the whole organization—on life in its broad, permanent, and universal significance. If the scheme for the preservation of any single individual fails, either through the failure of that individual or through the activity of enemies, Nature is determined that the species shall go on. Even where a species is wiped out, it almost never fails that something of that species has gone into another, or else that a new one takes its place. Life as a whole continues, and that appears to be the natural law of which we can be most infallibly certain.

Therefore the second natural law makes possible —makes even inevitable, one would say—the reproduction of life. In animals a delicate mingling of the sense and nerves with the sexual organs brings about mating; in plants the equipment seems even more marvellous and cunning to us. I am going to go later into the elaborate and beautiful devices by which flowers, for instance, attract bees, insects, or birds to themselves in order to get those living things to work for them in carrying their pollen from one to another; also into the fabulous provisions made in the individual flowers to fertilize their seeds. For the moment we can pass, too, the artful means provided by which seed is distributed: the pea grown round so that it will roll; the seed of the thistle attached to a parachute of down that will carry it for long distances; many weeds, like the devil's-claw, with seeds in pods or containers which have sharp fangs to fasten into the hoof or tail or coat of a passing animal and thus obtain a sort of blind baggage ticket to some far-away destination. It is in such themes as this that the student in Nature's school grows garrulous and enthusiastic.

Now, the power to fight for self-preservation and

the power to re-create itself are in every living organism: the third power is the power to vary.

I have already spoken about the influence on heredity that is brought in by the mother in the human family: the two sexes always contribute to that result, but it is, nevertheless, a part of the variation of which I am now speaking. On top of that, and of the utmost importance to the plant-breeder in his work, there is the power in the plant to adjust itself to environment and adapt itself to changed conditions. There is a third cause of variation in life—the addition of characteristics formerly undiscovered and unknown in a strain—and this cause Hugo de Vries calls mutation, that is—the sudden and unexpected appearance, in the form of a sport or mutant, of a new characteristic or even a new form in an individual. But in each case these variations may be accounted for, in so far as they register themselves in the individual, and, if impressed there by repetition, become fixed in the heredity passed on to succeeding generations, by the presence in Nature of the power to vary.

If there were no such power in the plant it would be a definite, limited thing from the beginning of time to the end; instead we find animals and plants and men constantly changing, acquiring new powers, taking on new attributes, developing new possibilities, and making the steady progress we must see in all of life. I do not mean that these variations in plants are always beneficial to the plant, or that they always result in what any one, from any point of view, could call an improvement. Thousands and millions of plants have varied and, as a result, have died. But when the variation produces an added power, or the adjustment or adaptation is to meet an inimical influence or condition, the plant becomes that much stronger and better suited to its environment, and therefore makes what all must recognize as progress, certainly *as far as the plant itself is concerned.* My task was to take advantage of this power to vary and,

using it, to produce, as far as I could, a plant that was improved *from the viewpoint of man*. The law was the same, the process was the same, and often the purpose was the same—but not always. For instance, solely from the point of view of the plum tree, it might be far more desirable for it to produce seed—in its stone—always; from man's point of view it would be better to have a stoneless plum, and I produced one.

All this has been entered into to tell you something of the last great lesson I learned in Nature's school—namely, that the oldest and most fixed characteristics of a plant were the ones hardest to change and most stubborn to deal with, and that what had been added to the plant—to its heredity—in the long processes of time were easier to influence and change in direct proportion to the length of time the plant had manifested those characteristics. For example, the most fixed and inflexible characteristic of a tree is to fight for existence and to re-create itself; later it learned to vary; later it learned to grow a fine protective spread of foliage to protect itself; later, perhaps, it learned to give its fruit a certain amount of sugar over and above the amount needed to protect its stone, or pit, properly; later, we'll say, it learned to colour its fruit, and so on.

It came to the place, in the end, where the plan had developed what I can almost call an artistic temperament—a response to demands for beauty and flavour and odour and so on. Most fruits, even in their wild state, have some beauty or flavour or aroma in blossoms or fruit, partly put there to attract bees and birds to help in pollenization or the dissemination of seeds, but also partly, I think, in answer to the universal urge of beauty in our universe. And those last additions to the plant were the easiest to influence when they came to my experiment gardens.

You might say that, of the æsthetic inclinations in fruit trees, the first is towards perfume in the blossom, then aroma or bouquet in the fruit itself, then flavour,

then what we call quality—that is, the texture of the flesh, the thinness of the skin, the content of sugar, the value as nourishment, and so on. The most æsthetic qualities in a fruit are scarcely sensed by many people; it takes an epicure to sense a high and juicy flavour or aroma or fragrance, just as a large number of people are not able even to catch the evanescent colours or tones in music, or overtones, because they themselves have not been developed up to it. Environment has not yet produced in them the last, delicate perceptions that are possible to them, you see.

Luckily I could get many variations in plants by crossing two, each of which had one or more characteristics necessary to my purpose, as hardiness, generous bearing of blossoms or fruit, early or late fruiting, or what-not. And combining heredities, by cross-pollenization, and thereafter selecting those individuals showing the strongest tendency towards my purpose, was one of the chiefest methods in my repertoire. It was here that there entered the one important process I relied on and which I had never seen stressed by anyone before me—the repetition, repetition, repetition, of one influence on one plant for one purpose, time after time, day after day, generation after generation, patiently, tirelessly, without ever changing my idea or deviating from my plain course, until, in the end, the characteristic or quality or power I wanted in the plant was so firmly fixed in it—in its heredity, you see, even though it was the very latest and newest part of that heredity —that it could no more be bred out or dropped out or lost than could the plant's tendency to send its root downwards and its leaves upwards!

These are some of the lessons I learned in going to school to Nature. Not all of them, by any means; not perhaps the most striking, new, or exciting of the lessons, but the ones that were fundamental and therefore most vital to my work in life. Even with

these lessons learned, I did not find it easy always to achieve my end—to lead or urge or tease or drive the plant into my way of thinking. Sometimes Nature seemed to throw my reward right into my lap; at other times I made an effort time and again, time and again, and grew almost discouraged. But then, perhaps, I would say to myself, "Well, I'll stay with it another year," and I would; and one day, without a bit of warning, there would be my long-hoped-for result jumping out at me the whole length of a row!

I do not envy any man living! I have never heard of any work or occupation or vocation that seems to me to rival that of the scientist, especially of the scientist who is equally a humanist and whose research and study and experiments and discoveries are all directed to the end that man may find this old sphere a better and more beautiful place in which to live. After all, every scientist is adding something to this result, no matter whether his work seems closely related to human needs and desires or not. For what you may think of in scientific work as useless, like the search for the North Pole or the naming of a new species of fish, is really a contribution to our knowledge, and knowledge is power, and a power that, sooner or later, will be needed and can be turned into the dynamo to give added possibilities to life.

VIII

From thousands of incidents let me choose one to show how exact (in practice, provided you have patience and industry and knowledge of your ground) can be the filling of orders in plant development. A Western canner, one of my best friends, is Mr. John H. Empson. He came to me one day a good many years ago and told me that there would be a great market for a small, sweet, succulent garden pea for canning. The canned French pea had long been a familiar commodity to grocers and consumers, but it was high in price and Mr. Empson was convinced that an American product could be made that would equal it in every respect.

"Do you think such a pea might be developed?" Mr. Empson asked.

"Certainly," I said, "Will you order it from me?"

He laughed. "I can tell you that, if you happen to get such a pea, I can get growers to specialize in it to great advantage. If I thought you could accept a definite order and deliver a definite product I would be glad to place such an order, but that is impossible, of course."

"Not at all," I said. "I know what you want, and will deliver it to you inside of eight years, perhaps less."

I knew then, and Mr. Empson told me afterwards, that he couldn't quite believe I was serious. But I was entirely serious, because I had given myself definite orders in hundreds of cases and delivered on practically all of them. Moreover, this garden-pea order was comparatively simple.

The French pea is actually a pea that is not allowed to come to full maturity, but that is picked, by hand,

when the peas in the pod have reached their most perfect state as regards flavour and sweetness. You see, as in most vegetables, the sugar content in the pea begins, as the time of ripening passes, to turn into starch, in which form it is stored for use in feeding the life-germ when the pea is planted and germinates. If you pick your pea before that turning-point is reached, the pea is sweet and deliciously flavoured, though not yet at its full size.

My first problem was to develop a pea that would be well formed, firm, and of uniform size when it was still not entirely matured, and it was there that I started. I chose good, uniform peas for planting, and I planted a large field of them. By selection I found individual plants with a tendency towards the sort of qualities I wanted; the chosen pods were carefully saved and replanted, and selection again made towards the ideal.

Meantime there was another vital requisite in these peas. It was all well enough for the French to pick their peas by hand for canning, because they could work cheaply and charge high prices; for California canners it was necessary to have peas that would reach the desired size and have the desired qualities almost simultaneously over a whole field—in short, the peas must be so characterized that they could be harvested by machinery, perhaps in one or two days. This meant that I must also select and re-select to get uniformity of ripening period.

My process was simple enough, but it required the application of infinite pains and patience. For instance, as the plan progressed, I harvested my selected seed only after counting the separate pods on each vine and the separate peas in each pod, choosing between vines otherwise alike in product, according to the quantity as well as the quality of the peas. The promise had been made that I would make delivery within eight years; as a matter of fact Californian conditions enabled me to plant two genera-

tions each year, and in six generations, or at the end of three years, I sent for Mr. Empson and told him his pea was perfected.

He was amazed and sincerely delighted. In the course of this work we had become well acquainted and very friendly; I refused to let him pay me, of course, because of this friendship, and turned the pea-seed stock over to him to use for his own purposes. The pea was called the Burbank Empson, and to-day it is one of the chief crops in a large community in this State. Here was a definite order, definitely fulfilled, five years earlier than had been promised; but it was not magical nor mysterious. It was simply an application of the laws of Nature as expressed in plant life, but that run through all life. It is an excellent, though small, example of what I mean above when I say that this field of endeavour is wide open to young men and women, and one that, while the rewards may be meagre because as yet there is no method by which the plant inventor is protected in the rights to his invention, will pay enormous returns in satisfaction and incalculable returns in the good of the race.

There are four divisions into which this almost untouched work may be divided: first, improving the quality of fruits and vegetables and the beauty and fragrance of flowers; second, adapting plants to new environments and increasing the range of climates, soil conditions, and so on, in which they will thrive and bear; third, developing plants so that they will, because of characteristics and strengths impressed on their present heredities, waste less time and vital force, and therefore have more of both with which to increase their yields; and, fourth, developing wild plants now unknown or unused by man into useful and valuable servants and friends.

Of all my developments probably that best known and the results of which are most widely distributed and capitalized on by growers is my development of the plum. And nothing could give a clearer idea of

how all my work was done and how results were made possible than by telling you something of the history of my experiments with this fruit. There are many other trees and flowers in which I have met with greater difficulties, from which I have learned more, and which have given me greater personal satisfaction, but the widest application in practice has, thus far, been made of the large variety of plums I have produced. Let us go back to the beginning of this fruit tree, then, and trace the steps of the work, in order that you may understand what plant development means and how it is achieved.

Almost anywhere in the United States you can find, in wild, natural state, at least scattered members of the wild-plum family of trees. We have no definite way of knowing where the plum originated, but probably it was in that interesting and ancient triangle roughly pointed by the Caspian and Mediterranean Seas and the Persian Gulf to which scientists trace many of our plants and animals and somewhere near which, it is possible, the human race itself had its beginnings. The plum became widely scattered though, and this is not surprising when you consider its beautiful colour, its firm flesh, its unique flavour, even in the wild state, and its hardiness, both of seed and tree. It could stand transporting over greater distances than the peach, the cherry, the pear, for instance, and it had in it the power to vary—to adapt itself to new climates and soils; it was tempting to birds and animals and to man, and they carried it about, either merely for the sake of eating it, or for the sake, as in the case of ancient tribes, of planting it and cultivating it for use.

Certainly it is found pretty much all over the world, and though the records of diligent investigators fail to show that it was a familiar fruit in ancient times, it must have been one that barbarous peoples ate, since only they could have carried and dispersed its seeds so widely. And this is interesting and important

because it shows that the vitality and adaptability of the plum make it available for development so that it can be raised, eventually, almost everywhere where any deciduous trees will live.

On the other hand, the plum, forced through ages to protect its life-germ in the seed from animals, developed a stone, or pit, that was large, very strong, and greatly exacting from the tree. I have said several times that the making of pit-fibre and the nut or seed of any plant is the task that puts the heaviest load on that plant; it takes perhaps from five to ten times as much strength and nourishment for a plum tree to make its pits and seeds as it does for it to spread new leaf or root growth or to develop its blossoms. Therefore the plum had less strength to give to fruit, and the result was a tree with a small, acid fruit and a large, very strong pit about the seed.

Perhaps it has not occurred to you that the building of railroads and the erection of drying-plants and canneries marked a new era in the race-history of plants, but it is true. What we speak of as orchards, especially in large fruit-growing sections, are new developments that were brought into being by modern invention—the improvement of methods of transportation and the working-out of plans for extensive drying and canning operations. Originally all fruits were wild; there was a long, dark era in their race-histories when they grew merely for the purpose of perpetuating themselves through blossoms to attract birds and insects to help in the process of pollinization, through fruits to tempt birds and animals to disseminate them widely, and through the protective pit and the fertile seed or kernel.

The pulp or flesh of the fruit, originally designed only as advertising, to attract customers who would help scatter the seed, fulfilled its purpose, and did it in a very perfect and complete way, for eventually men began to value the fruits so much that they not only transported the seeds but they planted them,

tenderly cared for the young seedlings, pruned and cultivated the mature trees, and introduced a new era into the race-history of fruits—the age of gardens. For a long, long time, considered from the viewpoint of human beings, fruit trees were made a part of every garden, so that the owner had fruit for himself and his family. The word would go around the neighbourhood, too, that Ak or Boris or Amos had a new treat in his garden, and he would find plenty of local customers to help him eat his plums or pomegranates or figs. But even if he went into business he could not reach a market very far from home, because, in the first place, he had no means of rapid transportation and, in the second, the fruit would not stand handling nor last long before it had to be eaten. The era of the fruit-garden, where the consumption was purely home consumption, was the second in the race-history of the fruit.

It was discovered that certain fruits, notably figs and dates, could be dried and in that condition carried over long distances and kept for months in good shape, and a certain amount of business was done in the dried-fruit industry; but nothing to speak of, considered in a broad way, until, within my own time, the steam-engine and the steel mill made possible the railroad. The third era in the history of the race of fruit trees of the world is the era of transportation and modern packing methods.

It was in my time too—it was not more than a few decades since—that consumers showed that they would pay high prices for fresh fruit, preferring it to canned goods or dried fruits. I saw that this would be true, but I was one of the first—in fact, for a time I was the only man devoting study and experiment to the end that fruits might be developed that would stand transportation and arrive in the hands of distant consumers in attractive condition. It was here that I began my work with plums.

I must recall to your minds what I have said pre-

viously about the two new ideas that went into my life-work: the idea that a man could use Nature's own processes in a wholesale and definitely planned way, and the idea that he could considerably speed up her processes. There is no clearer illustration of this than to compare the fashion by which Nature worked before man entered into the field at all, and the methods he used and the results he got, even in the most slipshod and indefinite style, after he began to raise fruit. It took the wild plum uncounted thousands of years to develop into the small, sour, undesirable fruit we find in our own woods and canyons to-day; in two or three short centuries, with nothing more than the most casual knowledge or care, man made the plum edible, fairly sweet, and measurably juicy by untrained selection and by cultivation. But he did not work by wholesale, and he did not work with any definite purpose or any single-minded enthusiasm.

I brought both to the task.

At the time I came to California there were three varieties of plums grown here, one of which was of very little use at all, and neither of the other two of which would stand shipping. About 1880 I was beginning to turn my thoughts more and more towards experiments; the nursery business was growing and profitable, but it seemed to me almost anyone could conduct a nursery, and it wasn't everybody who would (even if he could) carry on the extensive experiments in plant development that I was itching to get at. Of course I should have to make my experiments pay, somehow, or I should soon be up a tree; the nursery business had shown me that fruits were going to be in great demand in California, and, casting about for one that needed attention and showed inherent possibilities, I lighted on the plum.

At about this same time, with my mind alert to pick up any vibrations that keyed in with my slowly formulating plans, I was browsing in the Mechanics'

Library in San Francisco when I came across a book written by an American sailor about his wanderings in Japan, and in it there was a description of a "blood-red" plum found in the province of Satsuma. That sailor-man was not a skilled writer, but he certainly must have been a good trencherman, because he described that plum so that it made your mouth water to read about it! As far as I was concerned the red-fleshed plum of Satsuma was sold and the first payment made down! I was going to have it for California.

Of course I had neither time nor money to go to Japan, but I knew of a bulb dealer, Isaac Bunting, an Englishman, in Yokohama, and when I was in shape to start the plum experiments I sent to him and asked him to send me a dozen seedlings of Japanese plums. The first shipment arrived in the fall of 1884, but they were all dead! So, continuing some simple experiments I was performing with local plums, I wrote to Mr. Bunting again, and on December 20, 1885, I received what was probably the most important single importation of fruit trees ever delivered in America—twelve sturdy, healthy Japanese plum seedlings, among them one of the variety my sailor-man had described.

The Japanese, an island people, closely hemmed in by their environment, you might say, and strongly impressed by it, impress on all their products their own tastes and likes; on the plum, as they raised it, were impressed bright colour, succulence, prolific bearing, and a tree-habit of sturdiness combined with that crude, irregular form which so appeals to the Japanese. Behind their plums was all the wild-tree heredity running back through thousands of years, no doubt, and on that had been superimposed the other hereditary traits that had come to their plums through environment and their own selection.

I do not think that, in the sense in which I judge plant improvement, the Japanese went deliberately

about this work of making the plum characteristically Japanese. They had the seedlings, and when a good one came along they passed it around among the neighbours, and so it got a foothold. Repetition, repetition, repetition, put into the plum the habits and characteristics the people preferred, so that it mirrors them, in a way, and is marked with their trademark for me, as clearly as though it were stamped: "Made in Japan."

And two points are interesting here. The individuals in the Caucasian race are made up of such a number of world races that we get a greater variety of tastes among them. Some like a sweet fruit, some a sour, some a soft, mellow texture, some a crisp, firm one, and so on. Orientals are a less mixed race, therefore they have tastes in food and fruits more in common. The second point is that wherever you find cultivated leisure classes you will find a varied and complex diet; whereas a race largely made up of the peasant or lower class, with few nobles or higher-class people for them to know about and study and imitate, will have generally a coarse, simple fare and fruits, for instance, located inside a narrow range of flavours, textures, and so on. The Japanese, are, though, an æsthetic people, and this crops out in their fruit, because all their fruits and their flowers are remarkable for beauty.

The twelve seedlings Mr. Bunting had sent me went right to work, and from them I added considerably to my store of knowledge of the secrets of Nature as regards variation in plants. I was fairly familiar with the tree habits of the Japanese plum, from reading and from pictures; it amazed me to see how my seedlings took hold and how quickly they showed that they were going to surpass anything ever known in the hereditary lines behind them. For form, sturdiness, rapidity of growth, bearing power, foliage, and general characteristics they were astonishing. Here was something to be accounted for!

Well, I accounted for it, and later experiments I made, and many made by eminent laboratory scientists along the same general line afterwards, confirmed my findings. The facts were, first, that the enforced rest given the plants, as a result of being uprooted, carefully packed, and moved half-way around the globe, had enabled them to store up unusual strength, and, second, that the change of climate had so benefited the seedlings that they improved as a child might that had been sent to California for its health. The plums caught right on and became Californiacs in a few weeks; you couldn't find anywhere a better advertisement for rest and a change of climate, not even in the Chamber of Commerce booklets!

Here, then, is one of the processes by which variations in plants are started and, by repetition, repetition, repetition, become fixed in those plants until they separate them, in habits, powers, and characteristics, so widely from their parents and brother and sister plants that they are practically a different species. It is the process of giving the individual plant a new and more favourable environment. For not only does this frequently suit the plant better and enable it to carry its ordinary, known powers to a higher level, but it brings to light and expresses in the individual latent or dormant hereditary possibilities that otherwise would have remained submerged and, in the end, entirely lost. It is an example of the law of "use and disuse": the home environment does not call forth this latent characteristic such as the big and rapid growth of the plum seedlings, but the new environment does, and the characteristic springs up from the tiny germ tendency and use strengthens it and repetition, repetition, repetition, fixes it in the plant, and it increases in power generation after generation because it is used and called on and put to work and is not lying dormant, and threatening, as it probably would in the end, to die out in the heredity from disuse.

Those twelve plum seedlings from Japan were the foundation stones on which I built my plum experiments; two of them came out so well and were so great an improvement, not only on our home plums and on European varieties, but on the Japanese plums that were related to them, that I put them on the market in 1889, four years after they had landed at San Francisco. One of them, described in my year-book as "very large, conical, heart-shaped, red with white bloom; very good," was named "The Burbank" by Professor H. E. Van Deman, Pomologist of the United States Department of Agriculture. The second was a plum with red flesh, very juicy, firm, delicious in flavour and delightful in aroma: it was the very fruit, greatly improved in its new environment, and having developed in it all the possibilities latent in its ancestry, so long dormant there in Japan, which my sailor-man had described in the book I had read almost ten years before. It was a dream come true, and in honour of the province whence it was derived I called it "The Satsuma."

IX

THE introduction of the improved Japanese plums, Satsuma and Burbank, related in the last chapter was not the result of a plant-breeding experiment, strictly speaking; it was more the result of a college course which I gave those Japanese seedlings, taking advantage of the improvement they themselves showed as the result of the new climate and the rest I have mentioned, and after that a training towards my standards for them, which they took on eagerly and easily, and which made of them far better, far different, and far more valuable fruit trees than when they entered my school.

Meantime I had been accumulating more plum stocks and experimenting extensively with them. The ten left from my Japanese importation proved valuable as a basis for work; by selection for qualities that seemed to me desirable I got plums that were better than anything that had gone before them; after that I went at the work in blossom-time and began cross-breeding.

Every blossom has a number of pollen-bearing filaments that we call *stamens* and one we call the *pistil*. In the *anther* at the end of each *stamen* are produced the pollen grains, each containing a fertilizing sperm, or male life-germ. At the base of the pistil, on the other hand, in the *ovulary*, rest the *ovules*, or eggs. The pollen grains, often so minute that it takes a fine microscope to see them, burst from the anthers in due time, and by chance, by action of wind or insect, or by way of the bills of birds, some of them are transferred to the sticky stigma on the end of the pistil. From that stigma the sperms work through a thin tissue and start

throwing out a tube for themselves that eventually finds its way into the ovule, and there the sperms unite with the female life-germ awaiting them in this egg, and fertilization is complete and the beginning of a seed accomplished.

Fertilization is the whole process of uniting the sperm with the egg; in Nature the process may be completed in one individual flower or the pollen may be carried from the anthers of one flower to the stigma of another. Bees have a strange habit of sticking pretty closely to one variety, so that they are perhaps the most useful members of insect society in crossing flowers in the same family, which accounts largely for diversified colours—in the poppies, for example. But other insects are not so particular, and they will go from a honeysuckle to a pansy, from a rose to a fruit blossom—incidentally doing a lot of work that is lost because they carry pollen where it isn't wanted and can't accomplish results.

When man takes a hand he knows what he is about—or he thinks that he does!—and he employs cross-fertilization or, better, cross-pollenation, removing the pollen cells from the anther of one flower and carefully placing them on the stigma of another, perhaps of the same variety, perhaps of a different variety, and even, as I have done often, of a different species. The insects do some cross-pollenation, but it is at random, and only when the heredities of the two plants thus crossed run nearly enough parallel does the cross-pollenation bring about actual fertilization and, from it, growable seed.

As I said above, the time came when I was ready to begin my attack on the fixed natures of the plums through working with their blossoms, and I took my forceps and glass pollen-trays and went into the grounds when the air was heavy with the rich odours and the trees flaming with the beauty of their spring flowers. I began to cross-pollenate.

I do not know anything in the work of the plant-developer that offers him more pleasure and satisfaction than this process. Fellow to the bee, the humming-bird, the ant, and the butterfly, he goes from blossom to blossom, not attracted, as they are, by the flamboyant colours with which the trees advertise their wares, but by the rich possibilities inherent in the work; guided not by fragrances, as they are, but by his own records of the characteristics of the fruit, noted the previous year. In my pocket I carry a packet of sheets on which are noted the working name of the individual fruit, its size, shape, bearing quality, flavour, colour, size of pit, texture of flesh, and so on; on each tree I have a marker that identifies the individual and refers me to its record. Like a painter choosing the colours for his palette, I choose the qualities that I desire to combine in the fruit.

Here, the record shows, is a thin, spindling, unpromising tree that bears a firm, luscious, beautiful plum; beyond a sturdy and well-formed tree that gives a sour, unlovely, or small fruit. The pollen from the one goes on to the sensitive, sticky stigma of the pistil of the other, after this second one has been thoroughly cleaned of its own pollen. Next I come to a plum of gorgeous dress that has no aroma or flavour; I know a tree that bears a rich and juicy plum that is drab and unattractive. The two are united in this field marriage ceremony of mine. This seedling offered me, last fall, a firm, well-textured fruit that would be admirable for very late harvesting, if I could only make it *ripen* late. That one yonder is late, but has no other particularly valuable quality. A nice problem here very often, because the earlier fruit blossoms earlier, the late one sometimes almost too late for my marriage to be made possible. What do I do then? Well, I find one of the last blossoms possible to the early tree; I hurry to the late one and, to my delight, I find one

ambitious little bud rubbing its eyes and waking up to see what sort of a world it is coming into. The poky, late blossom, and the ambitious little early one are my field. And some people think that plant-breeding must be tedious and drab sort of work!

The crossing is finished, spring passes, the fruit begins to form, sun, wind, air, and earth do their appointed work, and the fruit slowly takes on colour and final form. I watch as eagerly as a child going every morning to see whether or not the cocoon he has found and put in a box filled with leaves has been opened by the butterfly. Is the tree going to bear well? Are the fruits well distributed on the limbs? Does the green fruit hang well, resisting wind and the shaking of the tree? What resistance does it offer pests and disease? These are only a few of the questions I must ask, and that the fruit must answer favourably, or it is doomed. Then the day comes when the first few fruits are ripe. There is a big minute for the plant-developer as well as for the man! Perhaps he has something that will add to the wealth of the orchards of the world, something that will present to mankind a new flavour, aroma, colour of flesh, quality, succulence, and delicious taste, or perhaps a step has been made towards one or all of these desirable ends. The first fruit is picked; it is tasted. What is the verdict?

But this is not all. As I have said once before in these papers, the mere appearance, taste, texture, sweetness, smell, and flavour of the fruit do not form a complete criterion of its value. Will it ripen without falling from the tree untimely? Will it pick well? Will it keep? Will it cook up? Will it make good jelly? And, even if it cooks well in the kitchen, will it satisfy canners? Or, to put it more fairly, has it special characteristics that make it a possible canning fruit, because in fruit that the big canners will take the growers of the world have a steady and strong and usually dependable market. On the

other hand, if it is not for canners, is it a shipping fruit or one primarily desirable for the home garden or orchard?

Test after test, trial after trial, experiment after experiment—acceptance, approval, partial satisfaction, a question, rejection; the fruit stands or falls according to its ability to measure up, not to one standard or two, but to a dozen, fifty, a hundred! And it must not be assumed that all this is accomplished in one year or two. I have worked for twelve years now on a nectarine that I am hoping this year will prove itself worthy of release to the growers of home orchards. I suppose that nectarine has cost me six thousand dollars in time and in actual expenses—if I get six thousand dollars out of it I shall be luckier than I have been with many of my varieties and new creations! As I have said before, we plant-inventors cannot patent a new plum, though the man who makes an automobile horn, not far different from the ram's horn with which Joshua blew down Jericho, can get a patent and retire to Southern California and wear silk underclothes the rest of his life!

In speaking of the costs of my experiments I must refer to the enormous number of plants, branches, grafts, and trees that prove utterly valueless, or of a value that seems doubtful to me, considering the high standards I set, and that must be destroyed. My method of speeding up Nature's processes costs me hard work and untiring study and thought; the wholesaling of my experiments—the second half of my method—costs me hard cash. Because Nature requires compensation in all life; what one gains in time or field for experiment in the plant world he must pay for in some other coin. I put my mind to cross-pollenation, and plan the work with infinite patience, care, and research, where the insects and birds and animals are used while they were about their own businesses, and their efforts are undirected,

random, and wasteful. Secondly, I want the largest possible number of variations to choose from, and Nature's laws make it possible for me to get them. But the penalty I pay is the expense of growing the tens of thousands that do not measure up, in order to have the material from which to select the twenty or five or one plant or tree that is what I want or, more likely, leans that way a little farther than its brothers.

Well, from perhaps twenty-five thousand separate and distinct experiments with plums I got at least thirty or forty that had merit and about a score that were a real gift to man. Of these a dozen are now to be found widely used in the orchards and home gardens of the U.S.A. and some foreign countries; a few have not yet come into their own, and one or two may never be generally enough approved to be well known. This is because tastes and demands differ widely; I do not hesitate to say that every single one of my approved plums is meritorious and a valuable addition to the list of accepted varieties, but I am much in the position of a silk manufacturer who, from thousands of designs offered him, chooses twenty to manufacture into dress goods. He may be a man of taste, discernment, and experience, but it is morally certain that he will be outguessed in certain directions by the women and the dressmakers, and that one or two of the designs he got out, at so much expense, good though they may be by any proper standard of taste or judgment, will be left on his hands at the end of the season, or bought sparingly and finally marked down with a red tag and sold for what they will bring. I have never had the experience of having to hold a remnant sale, myself, or to cut prices to get trade, but I have a few of my creations that are still unrecognized, and perhaps always will be.

Once a new variety is ready for distribution, I am confronted with the necessity of making all this

work and planning, and this final achievement, of practical use to myself and the world, and there are three methods by which this is done. I have referred to the plan of filling an order, as in the Empson pea. Not long ago I delivered a very important order to a silk-grower in Japan. It was a mulberry tree that, with about the same growing conditions and fertilization as the older varieties, would produce nearly twice as much foliage for the feeding of silkworms. When I had completed the long and complex experiments that ended in success, I forwarded the grafts to Japan, and thus the order was fulfilled.

The second method is to sell a new variety outright to a nurseryman or seedsman. By this method I am completely out of the transaction and the buyer can distribute as he thinks best. Very few of the varieties I have sold in this fashion have been given a name suggestive of me and my work, though most of the buyers, naturally, used my name in the beginning, as a help (which I am proud to say it was) in introducing the novelty. In time, though, the connection had been lost sight of, and that is why I cannot, without looking into my records pretty exhaustively, say just how many new creations and improved varieties, now in general use and in high favour in the orchards and gardens of the world, came first from my experimental farms.

The third method was one I should have preferred, if it had not been made impossible by the work involved and the time required. That is the method of selling direct to the final buyer—the home gardener, the orchardist, or the plant-lover; and the reason I should have preferred it above all others, and the reason I have, as far as I could, pursued it, is that it brought me into immediate and direct contact with the people I have found uniformly the highest type in the world, the people who grow things and take a pride in them and want the best of them, and understand the work involved in producing them.

X

THE NEW CREATIONS bulletins of 1893 to 1901 brought me to the peak of my activities. In eight years I disposed of no less than seven hundred different varieties of flowers, trees, shrubs, vines, and grains, and I had enough newspaper notice to have satisfied Barnum. Meantime I had started working on cactus with the aim of removing the spines from the plant and improving its size and nutritive qualities, having long been interested in the idea of producing something that would be useful and profitable for our great south-western deserts. This was one of my most interesting projects, and one from which, I am now confident, the world will some day reap an unbelievable benefit.

The most elaborate, the most expensive, the most painful and physically difficult, and the most interesting single series of experiments I ever made I made with the cactus. There were, to begin with, over a thousand known varieties of this plant listed, and it was necessary for me to obtain specimens of as many of these varieties as possible. Before I was through I had received, planted, and studied more than six hundred of the total number, and my farms carried the largest single collection in the world. As to cost, I paid collectors thousands of dollars for their labours in gathering the specimens and in transportation expenses in getting them to Santa Rosa. In addition I spent more than sixteen years at this work, and kept a sizable force of men at work off and on all the time assisting me. So it was expensive.

As to the painful and exhausting nature of the experiment series, I can only say that I would not go

through it again for all the rewards man can give! Knowing well the painful and, in some cases, the dangerous nature of the spines of the cactus, I began by exercising the most scrupulous care in handling the plants. But presently it was clear that kid-glove methods in a venture that forced me to handle as many as six thousand cactus slabs in one day would prevent any progress being made, so I gritted my teeth and shut my eyes and went into the battle. I emerged scarred, pitted, and as full of spines as a pin-cushion. I have no doubt that my skin has been pierced or entered by a million cactus needles; at times I had so many on my hands and face that it was necessary to shave them off with a razor or to sandpaper them down so that, as they worked into the skin, as they do, there would not be enough to each individual spine to cause more than a temporary irritation. This was only one phase of the physical difficulties encountered in the experiment; the cactus slabs are heavy to handle, they grow to enormous size, and some of them to a considerable height, and I had literally hundreds of thousands of them to deal with as time passed. So that the mere manual labour involved was tremendous.

But, aside from the reward of having produced a new and valuable plant to add to man's store, I was well repaid by the cactus in the interest its life-history and its development during the work had for me, absorbed as I have always been in the miracles and marvels of Nature. Every step of the long series of experiments was full of delight for the naturalist, but more than anything else I was gratified to be able to prove, through this series, two of the fundamental laws that I maintain underlie all biology.

The pliability of life—the capacity it has for varying so that successive generations acquire new characteristics, new possibilities and powers, and new advantages, and the capacity for adding these new things to the heredity so that definite improvement

is continuous—was one of the first fundamentals I discovered through my early work with plants, and on it I based my experiments. I had proved it time and again to my own satisfaction, but the cactus gave me a demonstration that there could be no possible question about. It is so important a law and so significant to man that I want to tell the life-story of the cactus briefly to make the point clear.

While varieties of the cactus family are widely scattered through those territories of earth where the climate is hot and dry, the greatest assortment and the most numerous growths are found throughout the South-west and in northern Mexico. What we call the south-western deserts were once ocean-bed. Constructional and sedimentary changes occurred that surrounded great arms of the sea and cut off the sea-water from the parent bodies, forming inland salt lakes. Evaporation was greater than rainfall and the lakes began to diminish.

As dry land appeared, plant growth found footing; among other growths were the progenitors of the cactus we know. But they were entirely different in nature and characteristics—instead of great, pulpy slabs they grew small leaves from slender stems, they were smooth and harmless, and they developed small, bright-coloured flowers, and bore small, probably acid fruits. They were attractive to insects and animals, because the cactus plant needed to advertise to insure the dissemination of its seeds. Due to the presence still of large bodies of water, the climate was moist and warm, and the cactus flourished.

But as evaporation continued to decrease the size of the inland seas, and finally to dissipate them altogether, the climate changed, the heat became more intense, rains grew less frequent and less generous, native plants that could not adapt themselves rapidly enough or that did not have in their heredity the stamina to withstand the rigour of the new climate,

were crowded out by the sturdy cactus, the sage-brush, the greasewood, the mesquite, the salt-weed, and so on, and gradually disappeared. Now began an era of terrible trial for the plants. The change to desert, once started, was comparatively rapid—that is, instead of completely altering its nature in fifty thousand years, these south-western sea-beds may have been transformed into desert in a few hundred. It was speedy travelling for plants, and only the most adaptable could keep up the pace.

Not only this, but the death of other vegetation in those regions left the surviving varieties prey to all the herbivorous animals which ranged there; in self-defence the sage became bitter, the salt-weed dry and unpleasant, the mesquite like iron, and so on. The cactus, succulent, growing larger leaves as it needed to store more and more moisture, and full of sugar accumulated to carry it through hard periods of heat and the well-known bitter cold of desert Januarys, became more tempting to animals instead of less. Probably they were stripped of their leaves so often and over so long a period that they ceased to produce leaves almost altogether and grew more and more to slabs. They were robbed of their fruits, gnawed at, wounded, cut off at the base, and generally so hardly treated that they were threatened with extermination.

Finally there is no doubt that a few of them, struggling to put out new leaves from a bleeding stump, level with the ground, grew on that stump a small slab that carried hairs or protuberances and these hairs, in generations and generations, became stiffer and harder until they were spines; the spines grew more and more hard, sharp, tough, and plentiful. This protective armour was not developed in a hundred days or a hundred years or a thousand, but it *was* developed, definitely, for a definite purpose and with definite success in the end, and became so modified and adapted to the purpose for which

it was brought into being that the time came when a buffalo or an antelope or a rabbit could get exactly as much satisfaction out of a porcupine or a two-thousand-volt electric wire!

Now, how do I know that this development of the cactus spines was the result of a definite need and built up by the slow acquisition, generation after generation, of new and vital and slowly acquired characteristics? I know it, and no logical mind could deny it, but how can I prove it to the satisfaction of science, which takes nothing for granted?

I will give you my proof.

Innumerable cactus plants exist that have no spines whatever and are as tender and succulent and attractive to animals as the desert plants, but these harmless varieties and individuals are always found growing in crevices or cracks or caves or inaccessible places where no herbivorous animal could possibly reach them!

And I will give you another proof.

In sixteen years, by crossing cactus with few spines on cactus having spines, but possessed of desirable qualities such as great size, rapid growth, extreme succulence of leaves, and so on, I have carried the cactus back to the day when it had no spines because it needed none, and have perfected a spineless cactus in a length of time that, compared with the period which saw the change from smooth cactus to the vicious, armoured variety, is but a moment.

And incidentally I want to add a remarkable fact that is both interesting and instructive in this connection. My spineless cactus slabs, when very young and tender, have growths on them that are plainly vestigial leaves—that is, structures with all the qualities and characteristics of leaves, as in the original cactus of prehistoric times, but that slough off soon because the leaf-bearing habit is not now more than dimly in the heredity of the plant. These

vestigial reminders or remains of real leaves could be developed, by selection and proper cultivation, back into actual leaves, so that the cactus could be made to complete its round-trip from its first condition through its condition of an armoured desert plant and back to its first form once more! There is something more you will not find in the text-books, and it knocks a lot of so-called scientific theories into a cocked hat!

The other fundamental I have demonstrated conclusively with the cactus is more original with me and more important to my work. Because it was not necessary for me to prove that heredity is the sum of all environments—I know it from the beginning, since I first read it in Darwin, who believed it from the first to the end of his remarkable life, and it was just as much a fact to me as that plant life takes its force from the sun and that all other life owes its existence to plants, if you look far enough! I did need to demonstrate and prove the second theory, because my success was contingent on it, and without it I should have stopped as an ordinary seedsman or nurseryman and been known now only as "the Santa Rosa nurseryman with the place south of the iron bridge."

This second fundamental law is that adaptability—the power to vary to its own advantage in a plant, just as in a worm or a wolf or a man—depends on its history, its heredity, and is greater as vicissitudes and perils and struggles have been greater in its past.

In my work it was necessary for me to take advantage of every favourable fact and condition I could find. It was a long time before I woke to the fact that the heredity of a plant—its life-story—was just as important to me before I began to attempt a development of it as a clinical history of a new patient is necessary to a physician who wants to make a useful diagnosis. When I did, it was this

law that I discovered. The plant with the greatest variability was the one with which I could do the most with the least effort and with the greatest chance of success. The plant that had lived along for generation after generation without any trouble or stress or hardship or change in its condition and environment was as set in its way as a grindstone and as stubborn as a mule!

The cactus presented to me the most perfect possible example of the indubitable truth of this law. Take the rose, for contrast. For a thousand years, probably, men have trained and cultivated rose-bushes, giving them care, good soil, plenty of water and tending—the most favourable spots in the garden and the most jealous watching to protect them from enemies of every kind. The result is that the rose must have that sort of care continued or it will die as sure as moonrise? The nearer the rose is to the wild state the hardier it is; the more refined and high-bred and aristocratic, the more you have to sit up nights with it and give it a flannel overcoat and keep the aphis out of its hair. It has been bred to have nursing and attention, and so it simply lies down and quits if it does not receive it.

Take a cactus slab—born of generations, thousands of generations; of scorching heat, the attacks of enemies, the buffeting of winds, the parching, searing drought of summer, and the bitter, piercing cold of a desert winter. Throw that slab on the ground. From the eyes on the under-side will grow roots. From the eyes exposed to the sun will grow new slabs. How can that be? There is not a particle of difference between the eyes above and those below. What taught the cactus to seize at life in this fashion, adjusting itself to apparently impossible circumstances and doing the right thing at the right time and in the right direction? Heredity! The lessons its fathers learned, through bitter and almost fatal experiences through ten thousand years

of struggle for life. Throw a rose-cutting on the ground, and it will curl up and die like a fish out of water!

Put a slab of cactus away in a dark cellar. Almost anything else in the vegetable world would give up in a few days. Leave the cactus there for eight months or a year, and then look at it, and you will find that it has put out two or three or half a dozen feeble, pale, sickly slabs, or leaves, and is alive and kicking, and will simply jump ahead if you plant it in the poorest corner of your garden! I once hung a cactus plant in a tree, head down, for four years, and when I planted it, it started to grow within ten days. I laid a slab on a shelf that was covered with burlap and that was four feet from the ground, and presently I discovered that the cactus was developing new slabs and that its roots had gone through the burlap and were feeling their way along the cracks of the adjacent wall, reaching for that earth that was so far below it!

It has been said that my spineless cactus varieties are not a practical benefit to mankind, but I just let that sort of talk go in one ear and out the other. When I remember that in my own boyhood tomatoes were a forbidden fruit because they were considered poisonous; when I recall the difficulty I had in introducing some of my earliest plums to growers who have since reaped thousands and thousands of dollars from them and have grown them so long that most of them have forgotten whence they came; when I think of the bungling methods used in trying to produce valuable and splendid new varieties of every kind and sort of plant, and the mistakes that are made by farmers and orchardists and gardeners until experience teaches them how the new things should be utilized; and finally when I consider that very few men understand that the plant-developer is only the producer of the new invention, and cannot go out into the world and

experiment with it to find where it is most remunerative, what uses of it are the most profitable, and what treatments of it are necesary to make it most valuable to mankind, I do not worry about the spineless cactus.

It will grow with a minimum of care and cultivation on hundreds of thousands of acres now sterile; it is more than ninety per cent. water, sugar, and highly valuable mineral elements; it will produce from 150 to 300 tons of forage to the acre and, at the end of five or six years, one third as much fruit, which is nutritive and delicious; and it will multiply by division—that is, grow from slabs—indefinitely and with incredible rapidity.

The spineless cactus project, from first to last, was a big, bold one, from which I learned more than from any other one experiment, and that time will prove the value of to the world. If my contention is correct that this cactus of mine will thrive in arid and semi-arid regions and provide food for cattle, it will revolutionize our stock problem, make thousands wealthy and tens of thousands independent, and will re-create our deserts. If it is correct, there could not be a better illustration of the possibilities inherent in plant-breeding.

This has been my text for thirty or forty years—the need of more work with the plants on which the wealth of our planet is built. Not only have I preached it in season and out, but I have never begrudged the time necessary to the delivery of the sermon whenever I could get a congregation. I have always freely described my methods, principally because I wanted others to learn about the work, become interested in it, and ground themselves in its fundamentals so that they could proceed with it. Other fields seem more attractive; there are many other lines that are more sensational and showy.

But here is a world almost untouched by trained and enthusiastic experts; it is not Burbank's work,

nor is Burbank unique in it. I have gone farther than any one else, and operated on a larger scale, and accomplished something in more different branches of plant-breeding, but, as has been often repeated in these pages, I have only skimmed the surface of possibilities; with me and after me must come, not two or three, but hundreds of young men and women eager, industrious, patient, far-seeing, humble, to explore the field, map out its riches, and then develop them for the good of all mankind.

XI

READING biography, especially of men whose primary object has been something other than money-making, I have noticed that most of them sooner or later run into a promoter or a promotion and get badly singed. I have been no exception, though I must say that I do not believe any of the men who tried to exploit or subsidize me or my work had base motives. On the contrary, most of them were actuated by a desire to increase my usefulness and to widen the scope of my experiments and to broadcast the results over a greater area. No, I could usually smell out a rascal before he had reached the front door, and so could head him off.

I would rather have five energetic and competent enemies than one fool friend; now and again my friends have led me astray, and it has cost me a lot of money, a world of trouble, and a multitude of worries before I got back on the main track again. For more than twenty years I was embroiled in business relations with various people, and I had my wisdom teeth cut on some pretty tough bones in that period.

The spineless cactus enterprise attracted a great deal of attention; taken altogether I had quite a name. I had delivered a lecture or two and written constantly of my own speciality; a group of friends suggested that I should give up my actual experiments and go to teaching my methods to others at one of the big universities. In spite of the fact that I was definitely opposed to this project from the first, I was approached by several educators, and finally I did give a series of lectures as part of the regular course at Stanford University. But I steadfastly refused to turn teacher; what I needed was to

be free to attend to my experiments, which were still way up in the thousands year in and year out, and when the universities could not get me my friends went to work to obtain a subsidy for me so that I could have all my thought and energy to devote to the farms.

The result, after a good deal of activity on my behalf which was unsolicited and somewhat embarrassing to me, was that the Carnegie Institution proposed to give me a stated sum each year for expenses and to put some of its research experts at work with me to study my methods and record my results. I accepted with many misgivings which were later justified by experience. The sum paid me did not prove sufficient to meet my monthly expenses, and the experts sent found it difficult to get much data except by interviewing me. This took so much time that I had little left for experimentation—the sole object and purpose of my life—and presently the scheme was abandoned. I had always said, and said then, that my job was to create and get results rather than record the steps and details, and since the day held only twenty-four hours it was impossible to be an experimenter and a writer of scientific or practical books at the same time.

This experience led, however, to the business relationships I entered on, when I did actually try to do both. A book company was promoted which undertook to publish my writings, give me a royalty, and attend to publishing and marketing. For seven or eight years I was the busiest man on this planet; I suppose I wrote as many words as any one who ever lived, but the book people got into numerous difficulties, failed to live up to agreement, and finally went out of business, owing me almost a hundred thousand dollars.

In the meantime another outfit conceived the idea of establishing a company for distributing the products of my farms, and this "seed company," as we

called it, became an elaborate and complicated affair with a big office building, scores of employees, a large number of fat salaries for every one but myself, and a top-heavy business that resulted in disaster. Here, too, to add to my worries and my work, the promoters found themselves in deep water because they did not understand the business of selling seeds, trees, bulbs, and cuttings, and because everything they knew had to come from me. It was too much for me, naturally. Again I was the sufferer, to the tune of a good many thousand dollars, and in the end the "seed company" went into a receiver's hands.

These were the outstanding business experiences of my life, though there were numerous other adventures that were expensive and wearisome and even galling to me. From them I learned a good deal about men, however, and about the world of promotion, financing, share-issuing, share-selling, and share-speculation, and a great deal about my own physical limitations. The truth is that I should have kept to my own line, at which I had made a success both as a scientific plant-developer and as a business man; it is certain that no one with a big creative task can lean on the crutch of a financial subsidy or a financial arrangement and still have his hands free.

Every sort and kind and variety of crutch, in Nature and in man, is harmful except the prop that is made necessary by an actual physical deformity. In Nature the weaklings fall out of the race, and the plants or animals that cannot do their work and make their way unaided are dispensed with pretty summarily. Man attempts to support and strengthen himself with various aids and assistances, but it is rarely that his plan succeeds. The man or the institution that is really necessary and really efficient does not need an endowment. By that I do not mean that such organizations as universities should

be strictly self-supporting. The fact is that education, where it is free, is the job of the State—of Society—because the immediate returns from education go to the individual and not to the institution. Therefore either the public as a political entity has to supply the necessary funds or else the public as a group of voluntary donors has to do it.

But the fundamental law is there: crutches are for cripples, and they are weakening and debasing to a healthy, normal man. The individual must be self-reliant and, in a sense, self-sufficient, or else he goes down. By self-sufficient I mean able to employ his own efforts and capitalize his own abilities so that they co-ordinate with the efforts and abilities of others without putting any weight on them. Biologists call this symbiosis—the mutual help results from an interchange of activities between two separate individuals or organisms. It is interestingly and vividly illustrated in the relation between the bee and the flower.

Without the bee the flower could not, in many cases, pollenize even its own stigma, and certainly could not pollenize the stigmas of other flowers. Without the flower the bee could not live five minutes. The blossom, therefore, long ago learned to construct itself so that, somewhere below its reproductive organs, was a little pantry of sweets. Seeking that larder, the bee brushed against the pollen-laden stamen and not only scattered the precious grains about the place, but carried some of them with him to the next flower. Neither the bee nor the flower is a crutch; they are mutually helpful and mutually dependent.

Illustrations of that phenomenon can be found all through Nature; except for parasites, all Nature's children help one another; but all are self-sufficient too, and if they are not they fall by the wayside. Human beings practise symbiosis in almost every re-

lation they have with one another; they have added the refinement of wanting something for nothing, and sometimes they succeed in getting it. But not often without paying a heavy price either in public esteem or in humiliation or degradation or a weakening process of some sort. And the man or the organization that seeks to get someone else to do the work laid out to be done is absolutely certain to weaken himself, hamper others, slow up the race, and generally make a mess of his un-natural procedure.

Self-reliance and self-respect are about as valuable commodities as we can carry in our pack through life; the one depends on the other and follows it, and you will have to search a long way through Nature to find an instance where the individual relies wholly on another, and merely sponges his way. The parasite happens to grow through borrowing from a tree or a plant, but it has to find a place to take root, it must spread leaves and extend root-mouths, and resist enemies just as any other plant does. I do not present the parasite in plants as a model or pattern, but it has to be self-reliant and attend to its own job, or else it cannot live. The human parasite, as found in many forms and in many grades of society, scarcely does this. He is just an encumbrance and a load on his fellows; perhaps some day we shall take a lesson from the bees and kill off our drones.

The necessity for self-reliance and effort and ambition in the human individual is necessitated by the law. This law develops what is often called a struggle, and many people speak of the Darwinian theory of the survival of the fittest as harsh, cruel, and merciless.

But the struggle for existence is what makes the world what it is, both the dark side and the light and beautiful and inspiring. It was a struggle for existence that caused flowerless and dull plants to put out their advertising matter, in the form of entrancing blossoms, thus attracting bees and birds and bringing

about the fertilization necessary to their continued life. It was the same struggle that brought perfume into the world; it was the war of forces that gashed the earth with such wonders as the Grand Canyon of the Colorado, that broke open the rocks that form the magic glory of Yosemite, that created Niagara Falls, the Adirondacks, and that gave us the illimitable ocean washing the shores of our continents.

It was the struggle for existence that sent the elm, the walnut, and the redwood towering into space; that lays a blanket of white on the earth in winter and follows it with the effulgent beauty of early spring, leaping into renewed life in fairy robes of green, set with the gems of little flowers. It was the struggle for existence that gave us our farms, our cities, our steamships, our railroads, our factories, turning out necessities, comforts, and luxuries every day until life is becoming easier and sweeter for every human on this planet. It was the struggle for existence that gave us Mohammed and Christ and Charlemagne and Napoleon and Lincoln and Rockefeller and Edison, and all our pioneers and leaders and warriors and thinkers and doers in a world that is not made up entirely of failures and traitors and rascals, in spite of the gloomy writers and the liverish painters and the dyspeptic playwrights!

It is the struggle for existence, so called, that gives us all our beauty and sweetness and pleasure and health and love and happiness—our little children, our dogs and birds, our poetry and romance and song too. Because in the heredity of the race is a great questing and need and urge for beauty; that urge accumulates and accumulates, generation after generation, in a family of plain and undistinguished history, until finally it bursts forth in a Beethoven, a Keats, or a Whitman, in a Whistler or Abbey, in a Saint-Gaudens or a Christopher Wren. The need for beauty is as positive a natural impulsion as the need for food, though it is a later development, and therefore not so

deep-rooted and so all-absorbing; nevertheless you know there are people everywhere who will go without several meals to attend a musical programme or will sacrifice clothing to buy a picture. This æsthetic side of man, as in all Nature, is one of the last refinements added to the list, but because it is a younger appetite or need does not mean that it is not an important and even vital one.

The struggle for existence is not actually a struggle at all. You cannot sit beside the ocean and watch the breakers pounding, pounding, pounding at the cliffs, dashing their great weight at the rock, throwing rainbow-tinted veils of spray high in the air, and roaring into caverns and booming around reefs without being awed and impressed by the tremendous beauty of the scene. You cannot stand in a garden and contemplate the butterflies and the humming-birds and the bees sailing or whirring or darting from one lovely blossom to another without being rested and refreshed and gratified. Yet in both cases this impulse that is so wrongly called "the struggle for existence" is being perfectly exemplified before your eyes!

Is not the sea striving to batter down the cliffs and pulverize the rocks to sand and eat into the land to carry it away to fill its bottomless bed? Is not the butterfly hurrying to get its sip of sweet before death overtakes it and leaves it no time to mature and deposit the egg which will bring about a caterpillar that will turn into another butterfly? Is not the bee storing food for the hive to make possible the life of the swarm that is to come? Is not the humming-bird whirring through its work, hard-pressed to get a store of food for its little ones, tucked away in a tiny hammock-nest somewhere under a palm leaf or in a thicket of hedge? It is life or death for the sea and the land. Which will win? It is life or death for flower and bird and insect. But that is the hard and cruel and merciless and untrue picture of the business.

What is really going on all about us is a play of two forces. Is the law of gravity cruel and relentless? Is it a pity that that shooting star goes flaming through the heavens to disappear into space? Is the hunger of the baby or the absorption of the poet to put his thought into rhyme piteous? Is it a hard law that water quenches your thirst, that fire warms you, that food gives you strength, that electricity pulses in the lamp-globe and turns the filament white-hot to light your book as you sit reading this? And yet in all those you see two forces playing on and in and through Life. Call it positive and negative, call it attraction and repulsion, call it movement and rest —call it what you will; but by whatever name it goes it is two opposites acting and interacting and counteracting and reacting one on the other through the whole universe, and by its processes and procedures bringing into our existence pleasure and pain, hunger and food, thirst and water, heat and cold, joy and sorrow, success and failure, black and white, light and shadow, tears and laughter—the flaming star and the midnight blackness of a cave, a beautiful woman and a crawling slug, a cruel tyrant and a laughing baby, a redwood tree and the poison ivy, the abundant health of the athlete and the running and putrid sores of a leper!

Those who prefer see only the blackness, the slug, the monster, poisonous air, and deadly disease. For me I like to walk in my gardens and see this eternal interplay of the two forces as it appears in beauty and fragrance.

No; the struggle for existence, and the difficulties into which a few business relationships brought me, and the failure of trusted men, and the pettiness of a few, and the handicaps and weaknesses and debilities that have hampered me are negligible to me. At seventy-seven years of age I can look back with pleasure and delight on my experience. To me the struggle has been a game, free from bitterness, broken

only by just penalties, played with the utmost fairness under the rules, and leaving me now the sense of having won a few points and made a few first places and having been rewarded generously for my effort. The law of life, Darwin said, is the survival of the fittest; I would like to amend his statement and assert that the law is the boundless reward of the industrious, the courageous, the true—in short, of *the fit!*

XII

We are so accustomed to the use of figurative language in sermons, essays, and stories nowadays that it is sometimes difficult to make people understand that true science does not employ metaphors and similes, unless by way of emphasis or for the sake of clearness, but means what it says. That is one reason why science has a language all its own and why it has to invent new words to describe new factors or formulas or discoveries in the onward march of knowledge.

It is important for the reader to understand that, except to make my point clear or by way of the emphasis of fable, I have been writing in literal terms in these chapters. For instance, the repeated assertion I have made that Nature's laws are universally true and applicable is meant to be taken exactly as it is set down; there is no parable intended when I have said again and again that the same fundamental laws apply to the crystal and the star, the egg and the fruit, the birdlet and the seedling, the man and the elephant. And this common law of Nature results in a very exact parallel between the life of the plant which has absorbed me for almost seventy years, and the life of the world's greatest treasure, asset, and hope—the child.

In a little book I published a few years ago I went into this subject at some length; since that time I have been increasingly impressed with the analogy between plant-breeding and the breeding, rearing, training, and education of children. I am more and more convinced too that the underlying principles of my work have a definite significance in this connection, and I could not round out this harvest of my years without summing up my experience and

conclusions, feeling as strongly as I do that the simplicity of the principles and their enormous importance alike commend them to the thoughtful parent or teacher—to all, in fact, who are interested in children.

This subject is one to which great attention has already been given, but you will observe generally that the authorities are specialists in some phase of medical knowledge, of education, of pedagogy, of psychology, or of physical training, and very few of them have succeeded, in my opinion, in withdrawing from their professional points of view and taking a wide and impersonal look at the whole field. Certainly almost none of them have been naturalists, which appears to me to be the first thing every sound trainer or teacher of children should be!

If you wanted to break a horse, you could find books on the science of the veterinary, on horse-breeding, on horse-racing, on saddles and bridles, and on the nutritive value of various feeds; but you would have to read them all, and a lot more, if you were going to understand the horse sufficiently well to make him obedient, docile, useful, and a friend. If you were expecting to assume the responsibilities of parenthood and wanted to be competent to carry the job through in a workmanlike fashion, you would find yourself confronted with a whole library of books on pre-natal care of the mother and child, on obstetrics, on feeding, on bathing, on early training, on physical education, on psychology, and so on through the whole list, and yet with a year's reading I doubt seriously that you would find more than a scant reference to the fundamentals of life on which all that is true in your books must be based and without which every pretty theory and fanciful conceit and table of statistics is mostly guesswork and largely misleading.

What I have been trying to say in these chapters is that those fundamentals are amazingly simple and

plain to understand, and that any one who learns them and correlates them with the other facts of life and with his experience, as he goes along, can use them in everyday life. Because I love children and wish for every one of them a future bright and assured, and because the fundamentals of which I write are so understandable and valuable in all your activities, I want to set the principles down again and then elaborate on them a little as I find them refer to the breeding and rearing of our boys and girls.

First, then, all we know of life certainly is that it began with the cell that, by division, reproduced itself, giving the infant cell its own character and powers and also giving it the added power of varying so that it could adapt itself to a new environment. The infant cell matured, added a mite or mote of new character to what its parent had possessed, divided, and thus established a new individual that, in turn, added a faint touch of new power or new possibility or new nature to itself and passed this, with the characteristics of its parent, and of its parent's parent, on to a fourth generation.

Second, the diversification of life proceeded slowly and steadily from this repeated division and this repeated addition of new characteristics to the original powers and characteristics of the first cell. Colonies of cells were formed and became the nucleus of vegetable life, the beginnings of vines and flowers and trees and vegetables, each generation adding something, if it survived under the play of negative and positive forces—hardship, drought, water too salt for it or land too moist, and so on—to the possessions of the generations that had preceded it. Vegetable growths took on the new characteristic of motive-power, and animal life appeared, probably first as tiny monads in warm salt water, then as the beginnings of fishes, and finally as land animals. Each generation added something because it had to add to its inherited powers and possibilities or die,

and eventually the forbears of the animals we know came into being and, to be the heir to all the ages, Man at last appeared.

Third, the law of growth and development never ceased to operate, as it had from the beginning, and to-day, as much as in the dim years of æons ago, all the heredity of all that time and of all those changes comes to your new-born babe, just as there comes to it that sensitiveness to environment—to impressions from without—that was in the original infant cell, and just as there is in it the same old power to vary and to adapt itself to that environment.

Fourth, the more combinations there are in the heredity of the flower or the animal or the child of to-day, the more susceptible it is thus rendered to environmental influences and the more striking and potential will its variations be. It was this fourth law that has been the basis for my seventy years of successful work with plants: I found that by breaking up old heredities and recombining them I could bring under my hand a widely diversified number of individuals with which to work towards the end I had in view.

Fifth, by selection of the individuals showing desirable tendencies, and their cultivation, and by repetition, repetition, repetition of the impressions and surroundings that bring about those desirable tendencies, these can be fixed in the heredity and be passed on without change through an indefinite number of generations.

Here is a cell, perhaps immersed in brackish water in a warm climate. It divided and divided and combined with other cells and adjusted itself to the conditions in which it found itself, and finally became an organism with leaves and roots. It needed to propagate its kind through seeds—envelopes of cells—and it needed to bequeath to its plant-children increased powers of adaptability, so it sought to recombine its own heredity with the heredity of

another plant, and it developed flowers to attract insects to bring it pollen and to take its pollen away to other plants in exchange. There was the beginning, let us say, of the daisy.

The daisy became scattered to widely separated parts of the earth with widely different climates, and it gradually became several varieties of daisy, with a common heredity, but each with its own peculiar characteristics that it had acquired through the power it had to vary and adapt itself. So, when I came along, I found a Japanese daisy, small and waxy, a Michaelmas daisy in England that was large and showy but of poor colour, and the little New England daisy, which was sturdy and a profuse bearer. Nature had made these variations of the original daisy possible; I used Nature's own methods to recombine those three heredities. The result was seed from which there came an infinite variety of daisies, some of them only faintly like the parent plants, some of them like one, some like two, and a very few that combined all the best qualities of all three.

By selection I eliminated the undesirable plants and by careful cultivation I began to get more and more daisies from the two or three first successful combinations, that came true from seed with the waxy whiteness of the Japanese, the size of the English daisy, and the sturdiness and productivity of the one that I had known as a boy in Massachusetts. By repetition of this selective process, repeating, repeating, repeating the lesson I was trying to teach the plant, I came out at last with a gallant plant that will grow almost anywhere, flourish in any sort of soil, that requires little care, and that bears through a long season profuse loads of beautiful golden-hearted, wax-white Shasta Daisies!

Here is another cell. It recombines and expands and joins a colony and becomes, after thousands of years, a man. The man's heredity is combined with the heredities of a woman, a race is established, the

race goes on, migrates, tries new countries and new tasks, develops, adjusts itself, learns new lessons, is given new powers from its environmental experiences, and you, my readers, are at last produced, with a heritage of mixed and untraceable and countless generations behind you, and more susceptible, perhaps, to impressions from your environment than any of them. The husband has one heredity, the wife has another. Your child is born. There is the latest fruit of a thousand thousand years of slow, gradual development—the sensitive little individual stamped with its heredity, but tuned to receive and to be influenced by a million environmental pressures that will close in on it from every side and every minute of its life, from the moment of its birth to the instant of its last breath!

That child may be a Shasta Daisy. But the big majority of those born under our hit-or-miss system of bringing children into existence and exposed to the casual and unguarded influences of our helter-skelter system of rearing and education are New England ox-eyes, or dull English daisies, or spindling, unlovely Japanese dalsies. Are we going to stop there? Or are we going to go on and, by selection, cultivation, thoughtful care, and by surrounding them with the highest and healthiest and best environments possible, work towards a race of children that will be the Shasta Daisies of the human family?

Some one has said that the way to reform a child is to begin with his grandfather, but I would prove to you that that would do no good—unless you began with the grandfather when he was a child, repeated the process with his son, and then began early again with the same influences and the same programme with the child in the third generation. Since beginning with your child's grandfather's childhood is impossible, the next best thing is to begin with the family—the home. Your home, for instance.

In my gardens I was able to begin with the seed,

selecting it carefully to see that it was sound and free from impurities and from imperfections and that it came from good heredities. Since we seem loath to give much scientific care and thought to the health and vigour and cleanness of the young people who marry in these days, we must take the little plant where we can—that is, when it is first above ground and ready to receive impressions. And for every impression which a plant can receive the child can receive ten thousand.

All life, and particularly all animal life, is sensitive to outside impressions, but the child is far and away the most sensitive organism in the entire planet. Because it not only has instinct and feeling, as animals have, but it also has the imitative power, the power to remember, the power to compare, and the power to reason.

And remember also what I have so often referred to as my process of fixing impressions on the plant, which is relatively non-sensitive when compared with a child. My process is repetition, repetition, repetition, over and over, time and again, until the influence is strong enough from those repeated impressions to fix in the plant a new colour or fragrance or shape or size or quality, whether in the fruit or in the flower. Your child, so much more sensitive and with so many more powers of absorption, may get an indelible and lifelong stain from one impression; if the same picture is printed again and again on his mind it is certain to be as deeply fixed as though dyed there with the most permanent colour known to the whole chemist's laboratory!

Sometimes we marvel at the cleverness of children in seeing through people; perhaps your own child has shown what seems to you a remarkable ability to pick out the honest and fine man or woman from the one who is weak or silly or bad. The fact is that this is one of Nature's provisions, deeply impressed in the heredity of all life, to help the young growth

to recognize its friends and shun and protect itself from its enemies. A day-old chick will cower or run for the hen's wings when a shadow is cast on it from above—the hawk-fear is bred into the chicken for a thousand generations. A very young kitten, with its eyes just opened, will arch its back and spit at a dog. A plant will lean towards the sun as soon as it is above ground, just as it will droop and try to make itself smaller the moment a storm begins. No wonder your child sees through to the innermost character of people and things about it!

It sees farther than that too: it has an instinctive and penetrating capacity for reading motives and judging your actions, not according to their appearance, but according to what is behind them. Doesn't your own child discern almost immediately when you are lying to it? Doesn't it recognize injustice in your dealings with it? Doesn't it know just how far it can go into bullying you or cajoling you, and do you think it does not realize its advantage when you have to bribe it to obey you? A lie to a child is a thousand times more wicked than a lie to an adult, because the child not only sees through the lie, but it turns mimetically to lying as a useful and trouble-saving device. If you are unjust to your child, accuse it wrongfully, punish it unfairly, or show partiality towards a little brother or sister, you are doing a much worse act than you would be guilty of if an older person were involved. Because the child not only recognizes the wrong and suffers under it, but he stores it away for reference and employment later, and he has impressed on the sensitive plate of his brain the thought that here is another art to add to lying and deceit and the taking of bribes!

To my way of thinking, the most serious offence against the child is that of ruling it or attempting to rule or direct it through fear. I would give a longer prison sentence to a man or woman who frightens a child with the policeman, a bogy, a ghost,

a big black bear, or a big black dog, than I would give a burglar, for the thief only steals that which can be replaced, but the parent or nurse who instils fear into a child takes away its most precious possessions—confidence and affection—and replaces those fine qualities with cowardice, mental and moral. I have the most complete sympathy for religion and the deepest abhorrence of which I am capable for a lying theology. Weak or ailing or frightened or ignorant women and innocent and trusting little children have always been the favourite raw material of priests; luckily the day has already dawned when love and tolerance and a desire for righteousness are being substituted for fear and dread and falsehood and mummery!

XIII

DID it ever occur to you that only man-made laws prohibit?

Moses may or may not have been inspired to proclaim the Ten Commandments, but he certainly employed the human formula in more than half his rules of conduct. Jesus Christ, on the other hand, gave only two commandments, and both of them were affirmative, constructive, and positive.

Nature's laws are that way; they affirm instead of prohibiting. If you violate her laws you are your own prosecuting attorney, judge, jury, and hangman; Nature says you must eat sanely, sleep soundly, care for your body, avoid anger and hatred, be industrious, sober, and self-respecting; and if you flaunt her laws you just naturally walk right into the jail of indigestion, nervous prostration, ill health, a bad heart, worthlessness, and failure; there is no appealing the case, and there is no alibi possible and no one to whom to "pass the buck"!

In the preceding chapter I have drawn some conclusions from my knowledge of Nature's laws that have to do with the prohibitions in the raising of children, but that is only half the case. The precepts above cited, learned from seventy years of close application to Nature's ordinances, teach us what not to do. But there is a big and inspiring other side—the true natural laws that are affirmative and constructive. The first that comes to my mind is the law of fixing new and desirable characteristics in the little human plant through environmental influences.

In the last forty years I have proved time and again that there is not a single desirable power of which a given species of plants is capable that can-

not be impressed on it by breeding, selection, and repetition, repetition, repetition. I have given scentless flowers perfume, tasteless fruits flavour, dry-coloured blossoms, or those with a single hue, brilliant and variegated garments. Time after time, as already related in these pages, I have taken a definite order to produce a definite quality or set of qualities in a well-known and apparently unchangeable plant or flower or fruit and in a comparatively few generations have delivered the order. Choose any reasonable improvement you please in a plant and it can be accomplished; not only that, but it can be fixed in the plant so that, short of reversing the process employed or permitting Nature to reverse it—"letting the plant go back to its wild state"—it will remain fixed and unalterable in its new character.

If scientific breeding, careful selection, repetition, repetition, repetition of impressions, and tireless patience and strict adherence to the programme can achieve this in the plant world, how much more surely could a definite improvement be achieved with your children, more sensitive, more adaptable, and blessed with powers of discrimination, the gift of appreciation, and the ability to reason and compare for themselves? This is not to say that you can make your boy a great financier by early training, or turn your girl into a peerless musician if she has no aptitude for music. You cannot make the peony bear wheat nor the ivy produce roses. What you can do is give the peony sturdiness, variegated colour, the power to grow taller, or the habit of growing dwarfed; you can give the ivy some few new habits, within a limited range, but surely and definitely.

Why do we use as illustrations just here the peony and the ivy? Because, if I had used the plum or the poppy or the petunia I would not have been able to make so clear a parallel with the case of the growing child. The fact is that we have to take into account, in the training of the little human plant, a factor

that will be found in the list of five fundamental laws enumerated above that you must get clearly into your mind in thinking of the training of your children. That factor is heredity—a variant in its power and influence, both in plant life and in all other life. Let us look at that subject a moment, from the viewpoint of naturalists and humanists, lovers of all growing things, and under the light Nature sheds on all such questions.

I have said repeatedly that the more heredities are broken up and combined, or recombined the more plastic and adaptable is the resultant cross. You throw the plant out of its accustomed routine; you blow it into fragments as though with dynamite. Many of the old characteristics, traits, and tendencies on both sides are sent sky-high and never come down, but in the recombinations that do occur you catch heredity off balance, teetering and swaying, and for that reason the more ready to follow suggestions or leads given it from outside—that is, from environment. I have been the environment that was directing and leading in my plant experiments; that is just what I have been, an environmental influence, and a strong one!

I said in an earlier chapter that the reason I could work so successfully with the California poppy was because I found it a plant with an unbalanced and teetering heredity because of its comparative youth, and because it had had to adjust itself to widely different environments in order to live in the widely diversified climates and soils of its native state. So it was amenable to suggestions and responded to the push and the urge I gave it. But I should have hesitated a long time before beginning experiments with the oak or the palm or the ivy, or even the peony. Why? Because back of the oak trees, the palms (especially of the Californian and other deserts), and the ivy vine are heredities stretching down the centuries into an unknown dawn of time, unchang-

ing, unchanged, and perhaps almost unchangeable. True, the oak has developed into a considerable number of varieties, and there are many kinds of palms and a few of ivy. But generally speaking these variations have been but slight, so slight that you will find only a few people who can unfailingly distinguish between the varieties and name them all and describe their differences exactly. The main heredity line is a strong, definite chain, and the essential characteristics shown by all the links are so fixed that it would require a charge of T.N.T. to break them up; mere gunpowder wouldn't more than give them a slight shock!

Now we can go back to the analogy between plants and children with a new light shed on the discussion. You cannot make an artist out of a boy who cannot draw a straight line, we have agreed. Why not? Because, if he has no tendency that way and no ability that way, it is certain either that there is no artistic bent in his more recent hereditary line or else that, when that heredity was recombined with the heredity of another family—as in the mother's or the father's—your boy received bequests from other hereditary characteristics and the art-germ was omitted, or almost so. There are artists, on both sides, who have children with no tendency that way, though that is unusual. If it occurs it means that the boy got his characteristics from those members of the line before him who were clerks or clergymen or lawyers or business men or farmers or artisans, and that the æsthetic germ somehow contrived to come to him dormant or slightly or not at all.

Heredity and environment, as a matter of fact, are the two forces that are continually striving for the mastery in the plant or the animal or the human being. If the heredity is the stronger, the environmental influences will have to be tremendously increased in power to overcome the more static force that is in the heredity. Environment is galvanic,

active, positive; heredity is fixed, established, conservative—in this comparative sense, it is negative. There are many cases, both in my work and in life all about me, where heredity and environment appear to be equally powerful; when that occurs you have to stand back out of the way before the collision, because it will be like that of two locomotives—the irresistible force hitting the immovable post! The splinters fly in every direction, and the innocent bystander is the most likely victim.

In animal-breeding or in the development of plant life we start early and, as the experiment proceeds, remorselessly destroy the individuals that do not measure up. In human beings we cannot do that. If we could, our heredity problem would be attacked first, of course, through selection, then through breeding on a scientific basis, then through environmental pressure to affect gradual but sure improvement. As it is, the only thing we can hope for is to educate our young people to careful and high-minded choice of mates, then to begin to give their children environments that will discourage and thwart bad tendencies, foster and emphasize good ones, and add entirely new ones that point in the direction we want them to go, even though, in one generation, or two, or six, we cannot make very rapid progress. And it is in the hope that this fundamental programme will cause you to think a little that I am writing at such length.

I have been discussing the subject thus far on the premise that the human plants in our nursery are normally intelligent, normally healthy children. Such children, reared in normal homes, and especially such as are brought up in touch with Nature—in the country or the suburbs or the small town—are not a great problem to the race. We are fortunate in America in having a vast majority of our children situated in some such environment, and even in our great cities the children of the middle classes and of

the well-to-do have something of Nature brought to them in parks and playgrounds, though these are a bad substitute, in my opinion, for glades and hills and rivers and forests and the plains. However, we have a pretty good natural environment for most of our children, if we will take advantage of it; what we must discuss for a moment now are the children whose environment is bad, worse, or worst, and the children in the whole list who are below normal or abnormal.

One of the greatest fallacies of near-science and of amateurs in Nature's school is the belief that only from the normal can we get our best development and results. As a matter of fact Nature shows us again and again that it is from abnormalities that some of our most valuable and beautiful plants arise. Perhaps the very load and burden of great possibilities occurring by a chance recombination of heredities in a plant leave it little room for the characteristics most useful to its own continued existence. From that weak or abnormal plant—that genius-plant—may come the very characteristics we are looking for, and our only problem is to nurse it physically and keep it strong enough to pass on its overload of spiritual or æsthetic essences to its children.

How many of our great men have sprung either from weak or below-normal mothers or fathers; how many have themselves been crippled or deficient in some physical attribute? The list is long and impressive—more than that, it is sublimely inspiring. Physical defects or abnormalities may be due to the fact that the strength of the body has gone into a great soul or spirit or mind. I would be the last to condemn the weak or sickly or crippled; I have found too many cases where the physically subnormal or abnormal plant produced the finest and longest forward step in an experiment.

In the human plant, however, there is a power

that my flowers and trees do not have, except in a figurative sense—the power of mentality; the question of what to do where the child-plant is mentally deficient is one to be answered in love and pity rather than with cold science. Yet even here there is beginning to dawn a great hope and a great promise. For science has begun to find methods by which even the mentally deficient child can be gently but patiently pressed on by an environment of sunshine and pure air and good food, and by suggestion, education, attraction, and good sense, until there emerges from the darkened mind a little spark of intelligence that may be fanned into quite a flame in time. Repetition, repetition, repetition again finds itself justified as a method here. It must be self-evident that the hopelessly deficient mental person should not be allowed to jeopardize his fellows in a violent moment; it must be fully as evident that he must be restrained from jeopardizing the race by propagating his own kind. But mercy and kindliness and generous, healthful, patient care are the least we can give our little ones who, through some weakness in heredity or some accident in environment, come into the world cursed and burdened with the horror of imbecility!

XIV

In these papers I have tried to sketch lightly, and with broad strokes of my pencil, the development of my life and the progression of my work, my memories of men and events, the homely philosophy that has grown in my mind from my experiences and contacts, the lessons of Nature that have been learned through my association with that peer of all teachers, and the ripened thoughts that come to me whenever I sit down quietly to review my crowded, busy, profitable, and happy life.

I see the harvest of work accomplished and aims achieved—and here I observe that the crop is somewhat short of what it might have been.

I see the harvested experiences and lessons that have moulded and impressed and enriched my own life, and here there is a first-class yield, and more than the sowing seemed to merit.

I see the harvest of dear friendships, happy memories, recollections of triumphs won and honours bestowed: here the storehouse floor groans and the walls bulge and the shingles on the roof have to give a little to make room, for the harvest is rich and heavy and abundant, and we may even have to put on an ell or so to accommodate everything that is headed this way!

Looking backward down the seasons, it is very interesting to me to observe how the last crop has increased with the first two and seems to have been a result of them. Perhaps there is some significance in this fact.

When I began my life-work I was definitely not interested in money or in money-making, except as a means to an end, and when I lapsed, as I did once or

twice, and began to find myself a money-maker, I was compelled to execute a sharp right-about-face and get back to my original programme. I had no desire to be famous in the ordinary sense of the word, though I was actuated so strongly by an impulse to serve mankind that perhaps approbation of others was more of an incentive than I realized. I did have a great yearning to know, and it was not long before I was aware that there is no more useful key to the gates of all that this world holds for man than the key of exact knowledge.

I can remember now the keen zest I had for every sort and kind of information, whether it applied directly to my work or not, and the reason I remember it so clearly of that slight, active, busy nuisance of a boy and youth I was is because I have never lost it to this day. A library to me was a gold mine; a book was a trap skilfully baited to entice me in, head over heels! A man who knew something definitely could catch me with half a dozen words, and the great debt I owe some of the solid and substantial and learned men and women of wise years who were my father's neighbours and friends in New England can never be paid. I was not a bookworm nor a prodigy; I was much more certainly set down by my elders as inquisitive and sometimes a bother, but I did want to know, and I was unscrupulous in stealing something from any store that lay open to me and tireless (though maybe tiresome) in my anxiety to get at the plum preserves in the closets of other minds.

As a young man I had a good many hardships that were salutary and strengthening to my will and my purpose, even though some of them may have taxed me physically more than was good, but none of those trials and difficulties weighed at all against the growing power I felt through the learning I acquired from Nature, from the conversations of the experienced and the wise, and from books. I have referred already to the fact that my own course

through Nature's school brought me into close and invaluable contact with great and thoughtful and wise men and women; as my mind matured and developed I became more and more free of the honourable and delightful fellowship of those who are committed to the pursuit of knowledge.

If I have gleaned from these associations and this practice a wide and general education, it is no more than natural; the friendships that are mine, the honours that have come to me, the success I have had, the reputation I have gained, and the achievements of my life of work with flowers and trees are all due to my love of learning for its own sake and my habit of testing theories in practical application and of gaining from practical work the theories on which my conclusions about life are based.

Concerning the harvest of the years in work accomplished and aspirations achieved, the record is written in flowers and trees and shrubs and grains and vines now growing and reproducing themselves in probably every clime on this planet and in almost every country. My very first work was intensely practical: I saw a need for greater productivity, finer qualities, and sturdier plants, and I set to work to collaborate with Nature on this task. I had a secret ambition, even in those first years, that I have mentioned to but few people, and that was an ambition to work solely with ornamental trees. A few of the great and majestic trees of New England, such as the elm and the oak, as well as many that were dear to me for their beauty and grace, promised large returns in satisfaction if they could be duplicated in other families of trees less stately or less lovely; when I came to California I was ravished by the redwoods and California live-oaks, by the eucalyptus, then newly come to this country from Australia, and by the walnut.

Travelling about the countryside of Sonoma and neighbouring counties to-day, I am amazed myself to come on old friends standing in groups or lining

entrance roads or following fences—old, old trees that I planted with my own hands for my friends or customers, or raised and sold to them for their own planting. I had not realized how much time I spent in those earlier years on the growing of trees, nor how much success I had, in this new country, in inducing others to grow them. You will notice that the substantial, the thrifty, the worthy, and the likeable classes of people plant trees, no matter whether they are in a new and treeless country or in one already well planted, and that the shiftless, the transient, the careless, and the selfish are as little likely to set out sheltering trees as they are to be neat, thrifty, or good neighbours. Show me a developed town with no trees, and I will show you a town to avoid as a home for your families. Go through districts where want and squalor and crime and filth are the rule, and you will be lucky to find even a gaunt specimen of a tree anywhere about. This is not by chance; the planted and tended tree is as sure a sign of civilization as a revered flag or a church spire or a schoolhouse belfry, and the English, who have carried civilization to every part of their dominions scattered far and wide about the earth, plant shade-trees almost before they finish their houses or start their towns!

But my dream of spending my life working at the improvement and development of finer and bigger and more beautiful shade-trees was interrupted by the urge of more immediately practical needs of planters and gardeners and orchardists, and I was never able to do nearly as much as I always wanted to with trees. I brought together many varieties of walnuts in crosses, and from these developed two trees that have a definite and perhaps an incalculable value to the world. A hardwood tree that will grow rapidly and in temperate climates would, in time, revolutionize the lumber industry. The American Government's newer policy of reforesting timber

areas will probably perpetuate our softwood forests to supply the redwood, pine, and fir necessary to our country's needs for many generations to come, and if lumbermen can add to these old forests extensive plantings of a desirable hardwood the gain to builders will be apparent. My Royal and Paradox walnuts, at least, appear from practical tests to meet every requirement.

Meantime, though, my work had been more and more concentrated on the improvement of orchard fruits and the development of new varieties; it is a satisfaction to me to contemplate the number of new plums, prunes, cherries, pears, chestnuts, and other valuable varieties that have first leafed and blossomed and come to fruit on my farms. I have described my methods with these members of my big family sufficiently in these pages—the practical results of the work may be inferred. The work has not only brought into the orchards of the world numerous new fruits and berries, but the lessons learned, which were communicated, as fast as they were proved, to the world of plant-breeders and orchardists everywhere, have made possible an enormous and productive activity on the part of others. So it has been not only new trees but new ideas and new examples that have been found and developed and given out.

Still, from the purely practical angle some mention should be made of the work accomplished with vegetables. When you remember that all our vegetables a hundred years ago and most of them fifty years ago were accidental, purposeless, or incidental developments, by selection, from wholly wild and native plants, you can get some idea of the distance plant-breeding has gone with the vegetables daily on your table. Man had been sharing the roots and the green things and the vegetable fruits of the earth with the animals for ten thousand years before he began to study the possibilities for improvement in

them; true, he had picked over his leeks and corn and celery and green, eating the best and discarding the inferior pieces, and he had used some selection in saving the seed for his next year's planting. But this selection had been casual and instinctive—probably, in a sense, æsthetic; the real improvement came so recently that some of us can remember the poor strains in use in the middle of the nineteenth century.

My beginnings as a gardener led me to give this matter a good deal of thought, and I have already recounted a few of my experiences in improving table vegetables. For twenty-five years I worked with corn and tomatoes; I had a long acquaintance with peppers, chard, artichokes, asparagus, and other members of the tribe, and I demonstrated conclusively that there is no edible root or leaf so humble or so long used that it does not offer the plant-breeder an interesting and important field for research and concentration. There remains much to be done; what is more important, there are to-day, just as there have always been, an almost endless list of plants not at present thought of as edible, or as offering anything to man or beast, that can and some day will be bred and selected and improved until they will be added to the world's food supply. This sort of doctrine, preached in season and out, has been part of my job and part of my achievement.

Considered as a contribution to the material wealth of the world, my work with flowers has been least important of all, but I have said here again and again that the urge to beauty and the need for beautiful and gracious and lovely things in life is as vital a need as the urge for bread, even though it is a newer and less cultivated hereditary impulse than other appetites and cravings. It is very interesting to me to observe that beauty has been definitely listed on the stock exchanges of the world, and that art and decoration and the creation of lovely things

have been given seats on most of the boards of directors of the business institutions of our time. Long before this was generally true, I preached the doctrine of beauty as an asset and said that it was a need as definite in the human race as the need of clothing or the preservation of the species, though maybe not as strongly felt or quite as vital. I have preached it steadily for sixty years; perhaps I would have been "a voice calling in the wilderness," or would have been humoured as a tiresome but well-meaning old bore, if it had not been for the fact that I was able to prove my point and demonstrate my theory from Nature and in the experiences I had with people who showed a need for my creations and developments in flowers.

In an article I once wrote on orchids I find this note :—

"I have never worked with orchids, though I have studied them and grown thousands of the plants. The truth is that I could never interest myself in any but hardy or fairly hardy plants."

The reason is plain to me now, though I may not have recognized it then. I have not been plant-breeding for the benefit of the rich, with their conservatories and their artificial tastes, nor for florists who make fortunes out of exotic and expensive varieties. I have worked all my life for the people who love gardens and the beauty and utility of flowers, trees, and growing things and who grew them in the open field or garden, and who had no money to waste on extravagances or imported fads. Nurserymen and seedsmen have thought I ought to make a fortune; the reason why I did not may be guessed from this brief statement about orchids.

Yes, my harvest of the years in arduous work and in tasks boldly undertaken and patiently carried through is fairly large. There was much I wanted to do that I could find neither time nor money to under-

take; there were enterprises that failed and projects that had to be abandoned; there were disappointments and disillusioning experiences; there were periods of discouragement and days of ill health that interrupted the progress of the work. But taken as a whole, I suppose I have done my share and it is with a good deal of satisfaction that I view the record as, more mellow and less impatient than when I was younger, I look back over the pages and try to sum up their contents.

As regards my own work, I have long since ceased to think of it as anything more than a contribution to the whole body of knowledge and an addition, in its results and conclusions, to the technique and practice of plant development. For me it has become The Work. It still remains to be done—the most energetic and the most gifted and the most successful man could add only a little to the precious store of information and lay a board or two in the platform on which Science must stand. The horizon of plant-breeding, as one of the richest and one of the least occupied of all the territories of Science, is illimitable. On it a few men have sketched vague pictures of the possibilities yet to be realized. Only a hint of what may be done has been revealed to us. It remains for the next few generations to develop and expand the discoveries and explorations and acquisitions of the pioneers, but that there lies beyond that horizon a new world of beauty, utility, wealth, and good for all mankind cannot be questioned. I myself have had a little glimpse of the Promised Land!

If it were not for the tendency of strong, wise, and good men, of most of the women, and of practically all of the little children of the world, to want to get on the right side and make the pull an upward movement instead of a downward drag, I could well be discouraged with civilization. If I have seemed, in the last ten or fifteen years of my life, to be impatient with education and religion, it has been, not because

/am naturally fault-finding or troublesome, but because these two forces have always been powerful in the world and always will be, and their service and influence in the struggle have not seemed to me to have measured up to their stupendous opportunities. The religion that belittles or denies or stultifies knowledge and science and the search for truth is a false and dangerous religion, casting its vote on the side of darkness; the education that makes a machine of itself and turns all the steel of its children into the pins and needles of mediocrity is an influence on the conservative, and so on the reactionary side of the scale.

What is wrong with the world? Not commercialism, the movies, war, sensational newspapers, sex stories, short skirts, joy-riding, drinking, or jazz. It is the spirit and tendency and disposition of the human family; if we were on the right side, putting all our puny strength on the rope and heaving together on the upward drag towards better things, little details of conduct and little tempests of social behaviour and little fads and foibles and silly habits would be of no more weight than the fly on the back of the horse which leans into the collar and moves the load! It is what we are trying to win for ourselves and the world that counts, and if an automobile, a talking machine, and a season baseball ticket are all we care about having, those are about all we shall get, and our contribution to the whole Enterprise of Life will be as negligible as though we were Hottentots.

The state of civilization is not due to the length of time we have had religions or education or science or ideals; the present state of civilization is due to the use we have made of those factors. Their influence has been on the moral side, but has it always been on the ethical side? It has been long on formula and creed, but hasn't it fallen a little short on practice and elbow-grease? And influence is the greatest

power and force in the world. Nature teaches us that it is the moving, bending, impelling, directing, determining factor in all life, for without it we should be cells swimming in warm salt water to-day.

I believe in the immortality of influence.

It is the one sure, certain, permanent, eternal thing we can know positively anything about. It is in our own keeping and possession, it is ours to make what we will. It is given to us as the greatest and most potent gift of all our benefits and possibilities; we can strengthen and enlarge it by thought and study and care and the right heart, or we can dissipate and misuse it and so weaken it and ourselves and the race that we become negative and worthless and a load on the backs of our fellows.

Your influence is your birthright and your epitaph. It can make you ephemeral, inconsequential, or it can sing through the years.

Mankind has always been compelled to recognize the infinite forces which are beyond his control—fundamental lines of energy—force—which through long æons of the past have resulted in animals, plants, and man, an evolution from the simple to the complex.

Mental evolution is the reaching of a man towards more and more freedom from outside aid and the steady growing towards a better mental and moral fibre from within himself.

Do I ignore what is generally called the spiritual nature of man? No; it is the corona, the flower of life, the fruit of which is Altruism—the desire to help ourselves and others to higher and better thoughts and actions; in other words, to a more perfect state of harmony with environment.

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